# PROCEEDINGS

OF THE

# NATIONAL ACADEMY OF SCIENCES INDIA

1958

Vol. XXVIII SECTION-B Part V

OCTOBER, 1958

NATIONAL ACADEMY OF SCIENCES, INDIA
ALLAHABAD

# THE NATIONAL ACADEMY OF SCIENCES, INDIA

*(Registered under Act XXI of 1860)*

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**Annual Subscription for each Section : Rs. 30 (Inland); 60 sh. (Foreign)**

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OF THE

NATIONAL ACADEMY OF SCIENCES

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VOL. XXVIII SECTION-B PART V

# SOME SOIL FUNGI OF VARANASI

By

R. S. DWIVEDI

*Department of Botany, Banaras Hindu University*

Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957.

## INTRODUCTION

While investigating the biological and biochemical changes occurring in the soils, Adametz (1886), for the first time, isolated many species of fungi. Later on Oudemans and Koning (1902) made an attempt at a synthetic study of the occurrence of fungi in soil and their proper classification. Hagem (1907) and Lendner (1908) worked on Mucorales of the soil. These were soon followed by other investigators (Jensen 1912; Dale 1912 and 1914; Waksman 1916 and 1917; Goddard 1913; Gilman and Abbott 1927; Couch 1927 and others).

In India, Butler (1907) worked on Chytridiaceae and *Pythium*. Shaw (1915) recorded four fungi from Pusa soils. Thakur and Norris (1928) isolated twenty-five species from Madras soils with special reference to their power of cellulose decomposition and ammonification. Chaudhuri and Sachar (1934), Chaudhuri (1938) and Chaudhuri and Umar (1938) described many fungi from Punjab soils. Galloway (1936) made two hundred isolations of soil fungi from different parts of India. Ghatak and Roy (1939) recorded twenty-three fungi from a paddy field of Bengal. Saksena and Mehrotra (1952) published a paper on fungus flora of an Allahabad soil, in which they reported a few new records for India and some were reported for the first time from soil. Recently Saksena (1953, 1954 and 1955), while making ecological, morphological and taxonomical studies of soil fungi, published several papers from Sagar. Chattopadhyaya (1954) reported one new member of Ascomycetes from Indian top-soil.

The present paper deals with some forms of fungi isolated at different depths from a grass land.

## EXPERIMENTAL

The samples were taken as follows :—The actual spot for collecting soils was chosen. Afterwards, a pit 3ft. × 3ft. × 2 ft. was dug. The faces of the pit were carefully examined to record any stratification but no stratification was found. A vertical face of the pit was scraped off with a sterilised spatula. The first sample was taken from top six inches of the profile. The second was taken next six inches (7 - 12″) and the third from further next six inches (13 - 18″) deep. The samples were put quickly into sterilised cotton stoppered flasks provided for the purpose. Care was taken to scrape the face of the pit by a sterilised spatula just before the actual collection so that contamination of one soil with the other was avoided. The surface contaminations were avoided as far as possible.

After the sampling operation, the samples were brought to the laboratory and were crushed in sterilised mortar. The moisture content and pH of each sample were tested. In three 250 c.c. flasks, three dilutions viz., 1:100, 1:1000, and 1:10,000, with sterilised distilled water were prepared. From these three suspensions, one c.c. portions were transferred to sterilised Petri plates by means of a sterilised pipette and agar medium of the following composition was added to each Petri plate in the usual manner. Six plates for each dilution were prepared. The plates were incubated at 25°C.

Dist. water 1000 ml, dextrose 10 gms, peptone 5 gms, $KH_2PO_4$ 1 gm, $MgSO_4 \cdot 7H_2O$ 0·5 gm, agar 20 gms, Rose-Bengal 1 part in 15000 parts of the medium. Rose-Bengal was added to the original ingredient, then autoclaved at 15 lb. pressure for 20 minutes (Martin 1950).

Each colony was picked out and transferred to Czapek's agar medium (Thom and Raper 1945) and Waksman agar medium (Waksman 1927). After the isolation of fungi the hyphal tip cuttings and single spore transfers were made and purity of the cultures was thus ensured.

Moisture content and pH of the soils :—

| Soils | | Moisture content | pH |
|---|---|---|---|
| 1. 0 - 6″ | ... | 15·6% | 7·2 |
| 2. 7 - 12″ | ... | 17·1% | 7·4 |
| 3. 13 - 18″ | ... | 18·7% | 7·4 |

## FUNGI ISOLATED

Some of the fungi isolated from the spot are described below:—

*Thielavia terricola* (Gilman and Abbott) Emmons

syn. *Coniothyrium terricola* Gilman and Abbott.

Colonies on Waksman agar medium broadly spreading, composed of white, cottony, aerial and submerged hyphae, 3·6μ in diameter. Cleistothecia arising from an ascogonial coil, spherical, without ostiole, 80 - 200μ in diameter, generally 80 - 135μ, brownish to almost black at maturity, colour largely due to mass of dark spores within. Outer wall of cleistothecia of three layers, made up of thin walled

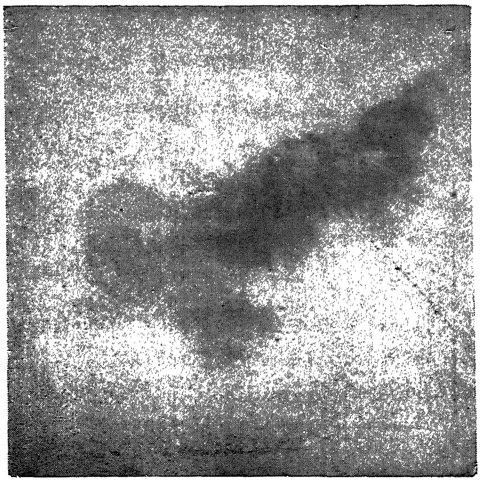

Plate I. *Chaetomium spirale* Photomicrograph of perithecia

Plate II. Photomicrograph of *Aspergillus* sp. showing proliferation of sterigmata into sterile hyphae.

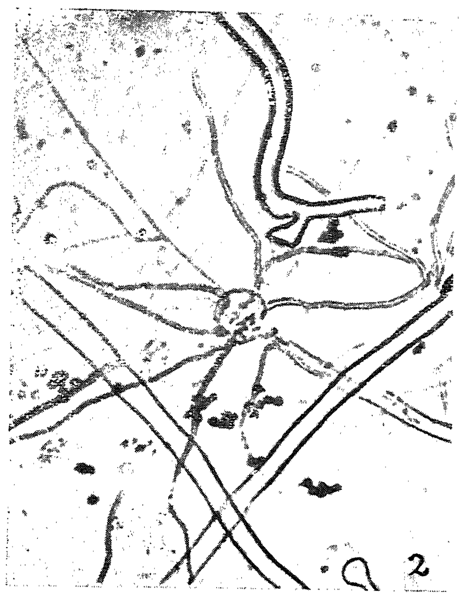

Plate II. Photomicrograph of *Aspergillus* sp. showing proliferation of sterigmata into secondary conidiophores.

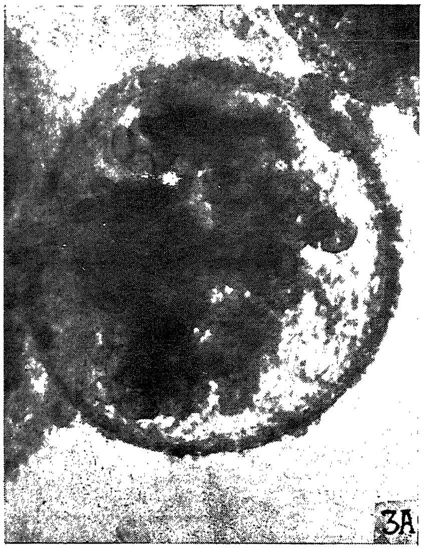

Plate III. *Thielavia terricola*:
Photomicrograph of cleistothecium with ascospores.

Photomicrograph of ascospores.

cells; asci deliquescing within cleistothecia. Ascospores broadly fusiform or elliptical, apiculate at both ends, dark, olivaceous (Colour Plate 15 L, 4 Maerz and Paul, 1930) to brown, 10·8 - 14·4 × 7·2 - 9μ (Pl. III 3A, 3B).

Isolated at the depth of 0-6" and 7—12". The isolate agrees with the type description of *T. terricola* (Gilman and Abbott) Emmons in every respect but the ascospores are double walled.

Isolated from soil :—MA (1933), Gilman and Abbott (1927), Chattopadhyaya (1954).

*Chaetomium spirale* Zopf.

Colonies on Waksman medium dark-brown to black. Perithecia 150 - 300 μ, globose or ovate with a bluntly pointed base. Lateral hair long, gradually tapering towards the tip, septate throughout, at base 3·6 - 5·4 μ in thickness, dark olive brown, sometimes smooth but more frequently roughened, terminal hair sparsely septate, roughened by minute spines, spirally coiled above with 6 to 12 turns; asci not seen. Spores ovate to lemon shaped, rarely rounded, apiculate at one end, hyaline when young, dark olive brown when mature, 9 - 10·8 × 5·4 - 7·2 μ (Plate I).

Isolated at the depth of 7 - 12". Reported from soil by Bisby *et al* (1933), Bayliss-Elliott (1930). The fungus appears to have been reported for the first time from Indian soil.

*Neocosmospora vasinfecta* Smith

Colonies on Waksman agar medium floccose, white; perithecia ochraceous buff to reddish at maturity, on the substratum, 350 - 415 × 160 - 180 μ, but generally less than 350 μ in length, wall pseudoparenchymatous, neck up to 108 μ in length and 116 μ in breadth but generally 90×80 μ. Asci cylindrical, dissolve to liberate the spores within the perithecia even when not mature, eight spores in each ascus. Ascospores globse to elliptical, wall pitted, wrinkled, 12·6 - 16·2 μ in dimater if globose, 16·2 - 12·6 μ when elliptical. Conidia (*Cephalosporium* stage) elliptical and average 5·4 - 10 × 2·7 - 3·6 μ. (Fig. 2).

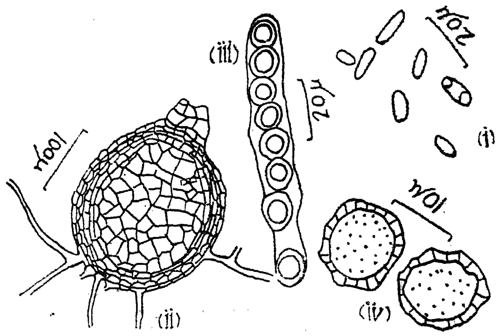


Fig. 2. *Neocosmospora vasinfecta*
(*i*) Conidia
(*ii*) Perithecium
(*iii*) Ascus
(*iv*) Ascospores

It has been isolated at the depths of 0 - 6″ and 7 - 12″.

It has been reported from soil only by Saksena and Mehrotra (1952).

*Pestalotia monorhincha* Speg.

Colonies on Waksman agar medium growing rapidly at 25°C, mycelia white with black acervuli; conidia having 0 - 4 septa but generally 3 septate, upto 18 - 28·8 × 5·4 - 7·2$\mu$. End cells hyaline, apical cells conical bearing 2 - 4 divergent setae but generally 3. Basal cell conical, abruptly contracted into a narrow pedicel, 2·7 - 7·2$\mu$. Germination of conidia in distilled water after 3 hours. (Fig. 3).

The fungus agrees with the description given by Saccardo (1884). It has been isolated at the depth of 0 - 6″. It is a new record from Indian soil. An unidentified species of *Pestalotia* has been reported for the first time from soil by Saksena and Mehrotra (1952).

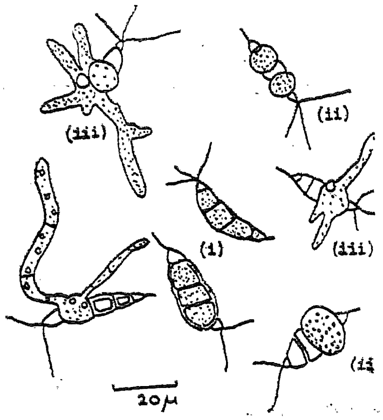


Fig. 3. *Pestalotia monorhincha*
(*i*) Conidia
(*ii*) Conidia before germination
(*iii*) Germinating conidia.

*Aspergillus* sp.

Colonies on Czapek's agar growing moderately, spreading upto 4 cm. in 10 days at room temperature (32°C), mycelia floccose, colonies yellowish-green, reverse at first light yellow then becoming yellowish at maturity. Conidiophores arise from substratum, more than 1 mm. in length and 5·3—14$\mu$ in breadth, septate; vegetative hyhae 3·5—5·3$\mu$ in diameter, septate; conidial heads globose, greenish-yellow, vesicle globose, sometime columnar varying from 12·4—36·6$\mu$ in diameter. Sterigmata in single series varying from 7—17·8 × 3·5—4·5$\mu$. Sometimes proliferation of some of the sterigmata into secondary conidiophores, latter upto 90$\mu$ long and 3·6$\mu$ broad

(Fig. 4). Sterigmata of secondary conidial heads upto 9 $\times$ 2·7$\mu$. Rarely proliferation of sterigmata of secondary conidial head into tertiary conidiophores, latter up to 50$\mu$ long and 2·7$\mu$ broad (Fig. 5). Number of sterigmata on tertiary conidial head 2—4. Sometimes proliferation of some or all the sterigmata into sterile hyphae (Pl. II, 1). Conidia smooth, globose, yellowish-green, conidial wall thick, 3·6 $\times$ 3·6$\mu$ to 5·4 $\times$ 5·4$\mu$ in diameter. Sclerotia numerous, brownish in colour.

The fungus was isolated at the depth of 0—6″. It differs from *A. proliferans* (George Smith 1943) in having very long secondary and tertiary conidiophores and proliferation of sterigmata into sterile hyphae. The fungus in question has stable abnormal heads.

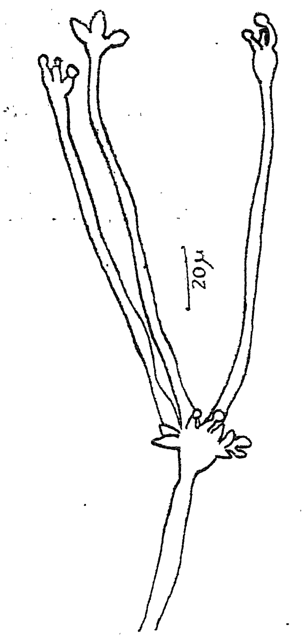


Fig. 4. *Aspergillus sp :*
Proliferation of sterigmata into secondary conidiophores.

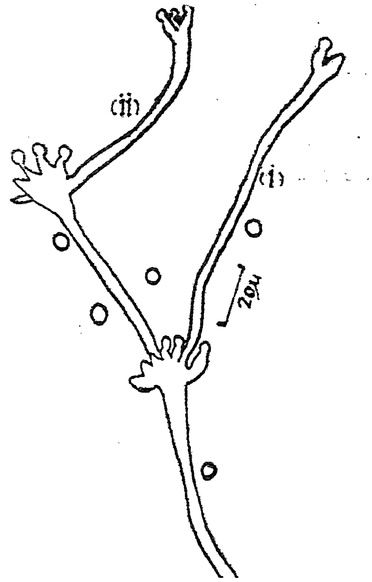


Fig. 5. *Aspergilluss sp :*
Proliferation of sterigmata into (*i*) secondary and (*ii*) tertiary conidiophores

*Aspergillus lutescens* Bainier

Colonies on Czapek's agar medium rapidly growing and broadly spreading, floccose, at first white, becoming rusty-yellow as conidial formation begins, finally becoming chestnut brown. (Colour Pl. 7E, 10) when conidial areas are mature. Reverse of colony pale-yellow, conidial heads radiate, hemispherical to sub-globose, buckthorn brown (Colour Pl. 13L, 8) to Dresden brown (Colour Pl. 14K, 8), comparatively small, 70—90$\mu$ in diameter when young, conidiophores 9—12·6$\mu$ in diameter, varying greatly in length, mostly short, arising from substratum or as branches of

aerial hyphae with walls pale yellowish and with pitting present ; vesicles globose to subglobose, 18—36$\mu$ in diameter. Sterigmata in one series in smaller and crowded heads, upto 14·4—25 × 4·5 - 5·4$\mu$. Sterigmata often in two series in larger heads, primary about 14·4—18 × 4·5 - 5·4$\mu$., secondary 9—12 × 4·5—5$\mu$. Conidia globose to sub-globose, varying from 5·4 × 5·4$\mu$ to 9 × 9$\mu$ if globose, 8 × 7·2—9 × 7·2$\mu$ if sub-globose, conspicuously roughened with prominent tubercles of colour. (Fig. 6).

The fungus agrees with the description given by Thom and Raper (1945). It has been isolated at the depth of 0—6″. It is a new record from India.

*Aspergillus* sp.

Colonies on Czapek's agar spreading rapidly at 30°C, at first white, becoming brownish-black due to production of conidial heads, on reverse pale-yellow colour, conidiophores 70—290 × 2·7—2·7$\mu$., double walled, conidial heads up to 25$\mu$ in diameter, globose, sometimes columnar; vesicles 9 × 7·2—18 × 18$\mu$; sterigmata in double series on larger heads and in single series on smaller heads, 9 - 12·6 × 3·6 —4·5$\mu$. Commonly proliferation of some of the sterigmata into secondary conidiophores, latter double walled, septate, brownish in colour, 90 - 138·6 × 3·6 - 4·5$\mu$ (Plate II, 2). Vesicles columnar or globose, 12·6 × 12·6$\mu$. Sterigmata in single series on secondary conidial heads, 5·6 - 9 × 3·6 - 3·6$\mu$. Occasionally proliferation of sterigmata of secondary conidial head into tertiary conidiophores, latter upto 55 × 2·7$\mu$. (Fig. 7). Conidia in chain, globose, brownish black, spiny, 3·6 × 3·6$\mu$ to 5·4 × 5·4$\mu$ in diameter.

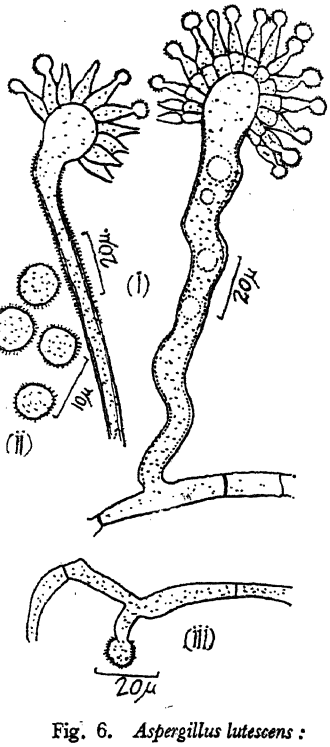


Fig. 6. *Aspergillus lutescens :*
(*i*) Conidiophores
(*ii*) Conidia
(*iii*) Germinating conidium

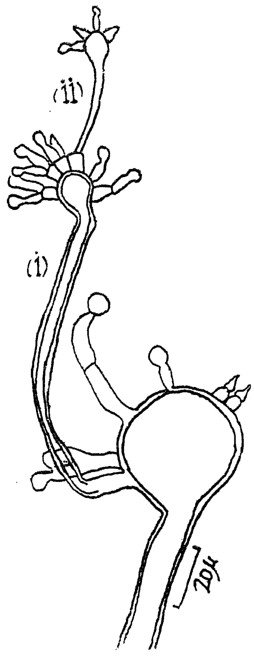


Fig. 7. *Aspergillus sp :*
Proliferation of sterigmata into (*i*) secondary and (*ii*) tertiary conidiophores.

The fungus has been isolated at the depth of 0 - 6″. No other species of the genus in *A. niger* group agrees with the above description. It differs from other species of this group in having proliferation of sterigmata into very long secondary and tertiary conidiophores.

*Paecilomyces fusisporus* Saksena

Colonies on Czapek's agar medium spreading with medium rate of growth, superficially consisting mostly of trailing fertile hyphae; colonies white at first, latter becoming cream coloured and then brownish. Hyphae branched, hyaline when young and brownish when old, 3·4 $\mu$, thick. Fertile hyphae septate, branched, creeping. Sterigmata irregularly distributed along the fertile hyphae, 10·16 × 3·6 - 5·4 $\mu$, with pointed apices bearing conidia in chains, conidia 6—9 × 3·6—5·4$\mu$, fusiform with the two ends pointed, in some, only one end pointed, brownish, walls thick, characteristic spiral markings from end to end (Fig. 8).

The fungus has been isolated at the depth of 7 - 12″. This is the first record after Saksena (1953) established the species.

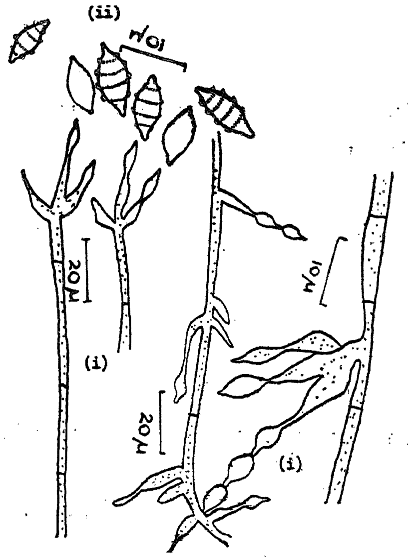


Fig. 8. *Paecilomyces fusisporus.*
(*i*) Conidiophores showing the formation and shape of Phialides and conidia.
(*ii*) Conidia.

*Botrytis cinerea* Persoon

The fungus on Waksman agar medium growing moderately, reaching a diameter of 4 cm. in 10 days at room temperature (30°C). Colour deeply grey in the centre. (Colour Pl. 14, L8) where hyphae seem to be floccose, at margin the colour is brownish black. Reverse deep blackish brown (Colour Pl. 16C, 9), margin at reverse brownish with tint of black colour. Conidiophore erect, unbranched, blackish brown, towards the tip somewhat hyaline, with several (three to more) projections at the tip from which condia are formed; conidia aggregated at the tip like a bunch of grapes.

Conidia stand so closely on the projection that thick heads are produced which soon fall off. Conidia ovate to elliptical, to almost globose, finely apiculate at the base, $5{\cdot}4-11{\cdot}6 \times 3{\cdot}6-5{\cdot}4\mu$, with slightly brownish wall (Fig. 9).

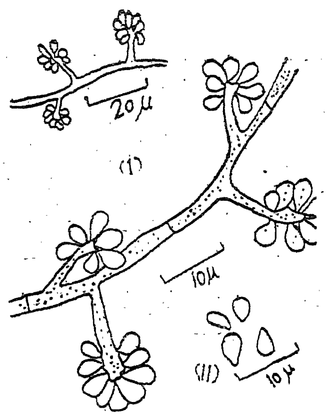


Fig. 9. *Botrytis cinerea* :

(*i*) Conidiophores showing shape and arrangement of conidia.

(*ii*) Conidia.

This isolate has been found at the depth of 0 – 6″. It has been reported from various parts of the world. Now it is being reported for the first time from Indian soil.


## SUMMARY

The soil fungi from a grass plot in Varanasi were isolated and identified. Only following genera have been described in detail.

*Thielavia*, *Chaetomium*, *Neocosmospora*, *Pestalotia*, *Aspergillus* (three species), *Paeci-Amyces*, *Botrytis*. *Pestalotia monorhincha* Speg. has been newly reported from soil. *Aspergillus lutescens* Bainier, *Botrytis cinerea* Persoon, *Chaetomium spirale* Zopf. and two more species of *Aspergillus* with proliferation of sterigmata into very long secondary and tertiary conidiophores in one case and with the same character together with proliferation of sterigmata into sterile hyphae in other case, have been reported for the first time in India. *Thielavia terricola* (Gilman and Abbott) Emmons, *Neocosmospora vasinfecta* Smith, *Paecilomyces fusisporus* Saksena, very rarely reported from soil, have also been isolated and described.



## ACKNOWLEDGEMENTS

The author has great pleasure in expressing his indebtedness to Dr. R. Y. Roy, for guidance and to Prof. R. Misra, F. N. I., for providing the laboratory facilities.

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*Original not seen.

# STUDIES ON THE EXCRETORY SYSTEM OF AMPHISTOMES OF RUMINANTS:

## I. *CARMYERIUS SPATIOSUS* (STILES & GOLDBERGER, 1910)

*By*

R. S. TANDON

*Department of Zoology, Lucknow University.*

(Read at the 26th Annual Session of the Academy held at Aligarh Muslim University on 3rd Feb. 1957)

The importance of the study of the excretory system of the trematedes was little recognised by the systematic helminthologists of the 19th century. It was in the early 20th century that this system attracted the attention of the workers. Since then stress has been laid on the study of the excretory system, in both the larval form and adult. Several eminent workers are of the opinion that a detailed study of the excretory system of the known trematodes and their larval forms would enable us to remove the doubts about the proper position of several genera and families. Looss (1898), Scinistin (1906), Odhner (1910, 12, 13), Cort (1917), Faust (1918, 19, 24, 39), Szidat (1924), Baer (1924), Sewell (1922), LaRue (1926, 38), Cort & Brooks (1928), Verma (1927), Mc Coy (1927), Dubois (1929), Stunkard (1929, 30), Fukui (1929), Woodhead (1930), Mehra (1931), Krull (1934), Faust & Hoffman (1934), Hunter (1934, 35), Willey (1934, 54), Benett (1936), Mc Mullen (1936), Resthchild (1937), Kathleen (1941), Thapar & Sinha (1945), Tandon (1949, 51, 55, 57, 58) described the excretory system of various trematodes. Cort (1917) was the first to point out the importance of the excretory system in the clasification of trematodes. This view was later on upheld by Faust, Sewell, LaRue, Kathleen and Willey. It is proposed to describe the excretory system of various amphistomes in a series of papers.

### MATERIAL AND METHOD

The material for the present studies was obtained from buffaloes (*Bos bubalis*) slaughtered in the local slaughter house at Lucknow during the course of the year, though *Carmyerius spaosus* is not a very common form.

The worms are flattened under pressure of the two slides tied together with a thread, are fixed in a concentrated solution of acidic corrosive sublimate for about 12 hours. After fixation the worms are washed freely first in tap water then in distilled water for an hour to several hours, depending upon the size of the worms, as thinner and smaller worms required a shorter washing period. These are then examined to see if corrosive sublimate has been properly removed from the external surfaces. These are then treated with 1% KOH for 1—24 hours, and washed again. The excretory ducts become black. Al though permanent Balsam mounts can be made, but generally the ducts becom faint in such preparations, as the black preci-

pitate filling these ducts gets dissolved in alcohol during dehydration. Hence it is proper to study the system in temporary glycerin preparations. This is supplemented with a study of the system in very small, live, immature worms which are available during certain parts of the year. It is easier to press these small worms under pressure of the cover slip and study the system even under high power. It also permits the study of both the excretory and lymphathic systems simultaneously.

*Carmyerius spatiosus* (Siles and Golberger, 1910)

(*Castrothylax spatiosus* Nasmark, 1936)

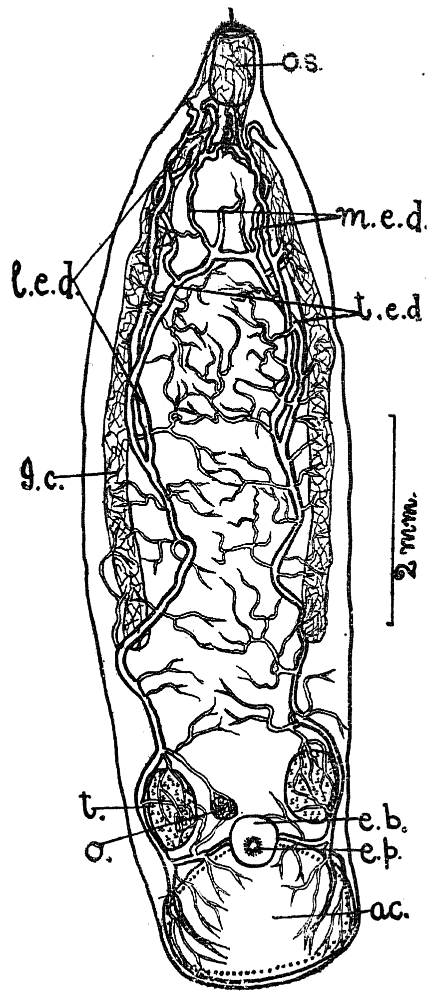
The Excretory System condists of a more or less H-shaped system of excretory ducts, though the horizontal connecting bar of the letter H is not placed in the middle but towards the anterior end of the body. The excretory pore opens dorsally, at the posterior end of the body, behind the opening of the Laurer's canal, either immediately in front of, or overlapping the acetabulum. The two longitudinal excretory ducts open on the ventral surface of the excretory bladder which is a small, rounded structure, placed dorsally overlapping the acetabulum. The two longitudinal ducts run laterally forwards towards the antertior end and terminate near the oral sucker. During its course, slightly anterior to the middle of the body, each longitudinal duct gives internally one branch which runs towards the median line and meets its fellow of the other side, a short distance away from the intestinal bifurcation, to form the transverse excretory duct. The transverse excretory ducts run parallel to the longitudinal ducts for quite a long distance before they unite with each other transversely, thus the horizontal bar of the letter H does not actually remain a simple straight bar. The transverse excretory duct receives two median branches from near the oral sucker and many smaller branches from the intestinal caeca, oesephagus, and the oral sucker in this region.

The longitudinal excretory ducts receive a large number of branches from the oral sucker, oesophagus, intestinal caeca, reproductive organs, body wall, and aceta bulum. The capillary branches of the excretory ducts form an anastamosing system around the intestinal caeca, which appear completely surround by their net work. The remotest port of the body of the worm is provided by these branches of the main ducts.

The capillary branches end in flame cells as in other amphistomes. Thus the excretory products even from the remotest part of the body are brought through the flame cells in the capillaries, which pour the products into the quarternary, tertiary, secondary and in the primary branches of the main ducts. The main ducts thus receive the excretory matter to pour it out through the excretory bladder, which serves as a temporary reservoir for these products.

The shining excretory granules seen in the cercaria of the amphistomes could not be seen in the ducts of the adult worms. The excretory ducts contained a transparent fluid, with small rounded, transparent bodies in them.

The excretory bladder was frequently seen contracting and expanding in the live worms. The flame cells could be seen with very great difficulty in very small, immature worms, because pigmentation of the general body of the worm and the other organs in the adult worms make it almost impossible to examine the system.




LETTERINGS IN THE FIGURE

ac.-acetabulum; e. b.-excretory bladder; e. p.-excretory pore; I. C.-intestinal caecum; l. e. d.-longitudinal excretory duct; m. e. d.-median excretory duct; o.-ovary; o. s.-oral sucker; t.-testis; t. e. d.-transverse excretory duct.

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# SOME STUDIES ON THE SMUT, *PERICLADIUM GREWIAE* PASS., OF *GREWIA VILLOSA* WILLD.

*By*

N. C. JOSHI*

*Botany Department, Government College, Ajmer (Rajasthan).*

(Received on 2nd September 1958)

## INTRODUCTION

In Ajmer (Rajasthan), *Grewia villosa* is severely affected by the smut, *Pericladium grewiae* every year which causes a considerable loss to the plants. The disease can be detected by blister like pustules which are covered by coriaceous hard woody indusium made of host tissue. A preliminary study of the morphology of the fungus, the symptoms it produces on the host, the various factors affecting spore germination (*i. e.* effect of salts, effect of sugars and effect of pH) was made by the author (Joshi 1958). In the following pages the writer has given some environmental factors influencing the disease and the manner of spread of the fungus in the host.

## REVIEW OF THE LITERATURE

The history of this smut is interesting, Passerni (1875) for the first time established this ganus. He considered it to be a monotypic genus belonging to order Uredinales. Henning (1900) later on showed that the fungus is a smut, not a rust and transferred it to the genus *Ustilago.* Zundel (1939) studied another smut helonging to this genus and named it *Xylosporium piperi* on *Piper* Sp. Mundkur (1944) bsowed that it ought to have been named *Pericladium piperi* and that the *Xylosporium* is only the synonym of *Pericladium.* Germination studies have proved that the smut studied by Zundel (1939), Mundkur (1944) and Joshi (1958) belong to the genus *Pericladium,* a member of the family Ustilaginaceae. In India at present only two species of *Pericledium* have been recorded viz. *Pericladium grewiae* and *Pericladium tiliacearum* (Mundkur & Thirumalachar 1952).

## MATERIAL AND METHODS

The material of *Pericladium grewiae* was collected from the following localities : Lohagal village, Adarshnagar, and Kishangargh road in Ajmer district. Specimens of the fungus in various stages were dried for 24 hours and then kept in cellophane bags till they were required for the studies. For determining the viability of the spores under dry conditions at different temperatures, small test tubes having lids at one end and for determining the thermal death point small capillary tubes, respectively were used. For infection experiments healthy seeds were obtained from Pachkund nursery. Healthy *Grewia* plants were selected for infection experiments at Lohagal village.

## ENVIRONMENTAL FACTORS AFFECTING THE DISEASE

The writer for the last 4 years carried out careful observations and noted that in the years 1954, 1955 and 1956 the disease was severe while in 1957 it occurred in

**Present Address*—Plant pathologist,
Plant Fumigation Station
Kiddirpore Dock, Calcutta-23.

a milder form. During the course of study it was observed that one on two heavy showers in July, followed by dry weather helped in the development of the disease as in the years 1954-1956; where as when July rains were delayed the appearance of the disease was also delayed; when it did break out the attack was only a mild one. Thus the weather and environmental-factors play an important part in the development of the disease.

## VIABILITY OF THE SPORES

Under dry conditions at different temperatures—

Some dry chlamydospores of the present smut were kept in a tube on 30th October 1953 in incubators at 5°C., 10°C., 15°C., 20°C., 25°C., 30°C. and 35°C. for 265 days. It was found that the spores were viable at all temperatures for 8 months.

## THERMAL DEATH POINT

In order to determine the thermal death point of the fungus the small capillary tubes were filled with the suspension of the spores of the fungus and placed at temperatures ranging from 40°C to 80°C for 5 seconds. The percentage of germination of the spores at different temperatures was noted and the thermal death point was determined. The T. D. P. of the fungus was found to be 59°C. In order to note wheather the spores were viable if they were in contact with ice, some of the capillary tubes were filled with the spore suspension and placed in ice, it was found that the spores did not lose the viability even after 72 hours.

## MODES OF INFECTION

There are four ways in which the smut can infect the host, (*i. e.* seed infection, soil infection, floral infection and shoot infection). Exhaustive experiments were carried out on the mode of infection. The results are presented below.

Healthy seeds were collected, sterilized with ·01% mercuric chloride solution, washed with sterile water and treated with (*a*) spore suspension (*b*) sporidia of germinated chlamydospores. No treatment was given to control seeds. The seeds were sown in sterilized soil in pots. For each experiment 15 pots were used. The pots were placed in green house and optimum conditions were provided. Results indicated that no infection was obtained either with spore suspension or with sporidia indicating that the infection is not due to seed borne spores.

Experiments were further conducted by incorporating viable spores in the soil and planting seeds of *Grewia villosa* in such soil. Proper control was kept and the pots carrying the seeds were given optimum conditions in green house. Here also the result was negative. No infection was obtained. Experiments on floral infection fared no better as no infection was noted.

*Local infection*—The writer adopted technique for producing infection similar to Hecke (1907). At first the suspension of the chlamydo-spores in 1% glucose solution was prepared and it was directly inoculated into the young shoots or twigs of the plants ·15 young twigs were taken for this purpose and inoculated with the spore suspension by means of a hypodermic needle on 10 July 1955. An equal number of branches were simply injured by the needle without introducing the inoculum. The exposed surface was wrapped with wet cotton for sometime. After 35 days the twigs were examined. Some small pustules of the smut were observed on some of the inoculated twigs while no such pustules were noticed on the control twigs as shown in table No. 1.

TABLE No. 1

Showing the results of the local infection expriments.

| Treatment | No. of branches inoculated | No. of twigs infected | Percentage of infected twigs |
|---|---|---|---|
| Inoculated with the spores in 1% glucose solution | 15 | 7 | 46·6 |
| Control | 15 | nil | 0 |

The results reveal that the shoot infection 'local infection' is the only normal method by which smut infects the host. The manner of infection is thus exactly that of *Ustilago maydis* (Brefeld 1890).

## SUMMARY AND CONCLUSION

As for *Pericladium grewiae* the writer has observed that one or two heavy showers in july and a short period of dryness is probably the most congenial environment for this smut. The possibility of variovs modes of infection (Viz., seed infection, soil infection and floral infection) has been worked out under the optimum conditions, but negative results.

Successful infection has only been obtained when the inoculum was introduced through the hypodermic needle. This would indicate that in nature spores get entry through injury of young tissue. Thus here also local infection like that of *Ustilago zeae* (Brefeld 1890) seems to be the normal method of initial infection.

The spores which matures sometime in the months of June and July and the coreaceous wall, which is made of host tissue covering the sori, ruptures and the spores which are liberated fall down on young twigs, germinate there, and directly infect the young part of the host tissue.

The writer thinks that the removal of the smutted twigs can prevent the spread of the disease, this probably is the most practical control measure against the smut.

## ACKNOWLEDGEMENT

I am greatful to Dr. G. W. Fischer of State College Washington, U. S. A., Dr. Lee Ling of F. A. O., and Dr. D. B. O. Savile of Canada for sending the literature on smut fungi. My thanks are due to Principal and Prof. B. Tiagi for labotatory facilities.

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# ENTOMOLOGICAL SURVEY OF HIMALAYA*

## PART XXVIII.—NIVAL COLLEMBOLA FROM THE NORTH-WEST HIMALAYA

*By*

H. N. BAIJAL

*Formerly of the School of Entomology, St. John's College, Agra*

In four earlier papers[1] I have described a part of the Collembola collected by the Prof. Mani's Entomological Expeditions to the North-West Himalaya during 1954-56. This paper deals with a part of the nival Collembola from the same source, especially the material collected in Lahaul-Spiti. Of the 31 species of Collembola so far known from the North-West Himalaya, 15 occur in the nival zones; 16 more are added here. The types of the 13 new species described here are deposited in the collections of the Zoological Survey of India, Calcutta.

I take this opportunity of expressing my thanks to Prof. M. S. Mani for placing this interesting material at my disposal for study and for guidance. My sincere thanks are due to Santokh Singh, Leader of the Third Entomological Expedition to the North-West Himalaya, for help in the field. I am also grateful to the well known specialist in Collembola, Prof. Salmon of New Zealand, for valuable advice.

Suborder ARTHROPLEONA

Family Hypogastruridae

**Hypogastrura sonapani**, sp. nov.

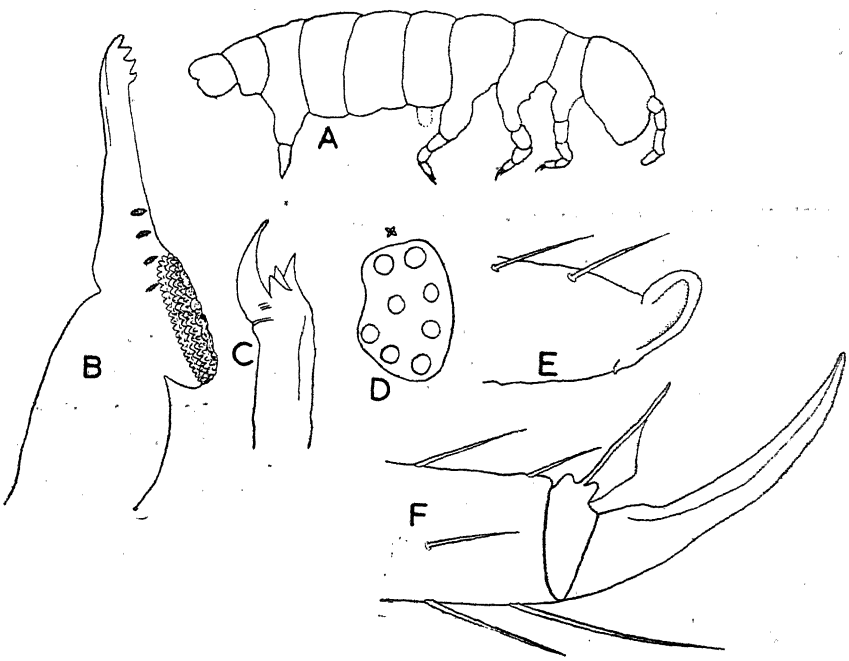



Fig. 1. *Hypogastrura sonapani*, sp. nov.

*Part XXVII of this series is appearing in this Journal.

[1] Baijal, H. N. 1955. *Agra Univ. J. Res.* (Sci.) 4(1):175-178; 1955. *ibid*, 4(2):531-538; 1955. *ibid.*, 4(Suppl.): 760-764; 1956. *ibid.*, 5(2): 373-376.

Length 1·5-1·8 mm. Body black when fresh and bluish-black in preserved specimens; clothed sparsely with short, simple setae, which are somewhat longer on the antennae and legs than on the general surface of the body; antennae a little longer than body; the 4 antennal segments in the ratio 4:5:5:6; the fourth antennal segment with sensory hairs; mandible with 5 incisors apically and in the molar area with 4 longer triangular teeth; maxilla head with 3 teeth; ocelli 8 on each side on raised pigmented area (fig. 1 D); postantennal organ smaller than ocelli and with 4 minute lobes; corpus with 2 setae; tenaculum with 4 lobes; claw elongate, without teeth (fig. 1 F); unguiculus half the length of claw and with broad inner lamella; a long simple seta basally on each leg; abdominal segment IV with a distinct, posteriorly projected process; furca short; manubrium equal to mucrodens; dens with 3 ventral setae; mucro rounded apically; dens about 7 times the length of murco; manubrium, dens and mucro in the ratio 9:7:2.

*Holotype* on slide, *paratypes* in spirit: Coll. No. 787/56, Sta. No. 53, Cardex No. 191 Seri Ice Fall, Sonapani Glacier, Purana Koksar Nal, Great Himalaya, 4500 m above mean sea level, coll. H. N. Baijal, 14-vi-1956; also numerous examples Coll. No. 972/56, Sta. No. 53, Cardex No. 192, Seri Ice Fall, 4500 m, coll. Santokh Singh, 14-vi-1956; Coll. No. 977/56, Sta. No. 53, cardex No. 192, coll. Santokh Singh, on open ice, partly covered by fresh snow, active during the night and early morning.

This species differs from *Hypogastrura narkandae* (Baijal)[1], previously described from the Sutlej Valley, in the absence of the anal spines, general black colour of the body, the shorter body setae, in the different proportions of the 4 antennal segments and other characters.

### **Xenylla obscura** Imms

1912. *Xenylla obscura*, Imms, *Proc. Zool. Soc. London*, p. 84.

1956. *Xenylla obscura*, Salmon, *Proc. R. ent. Soc. London*, 25 (9-10): 71.

I refer to this species 1 example, Coll. No. 718, Sta. No. 47, Cardex No. 145, Marhi alpine meadow, south slope of Pir Panjal Range, on a cliff to the north of mule track to Rohtang Pass, about 1·6 kilometres from the Marhi Gang Hut, rock ground, 3700 m above mean sea level, on rubarb, coll. H. N. Baijal, 20-v-1956.

The species was originally described from Simla and later recorded also from Sikkim. According to Salmon (*loc. cit.*), the claw has distinct inner tooth at two-thirds of its length, a long slender, basal seta on each side, there are also two distinctly clavate tenent hairs.

This is the first record of the species in the Beas drainage area of the North-West Himalaya.

[1] Baijal, H. N. 1955. *Agra Univ. J. Res.* (Sci.) 4(2): 531-532 (under *Achurotes*).

**Womerselya marhia**, sp. nov.

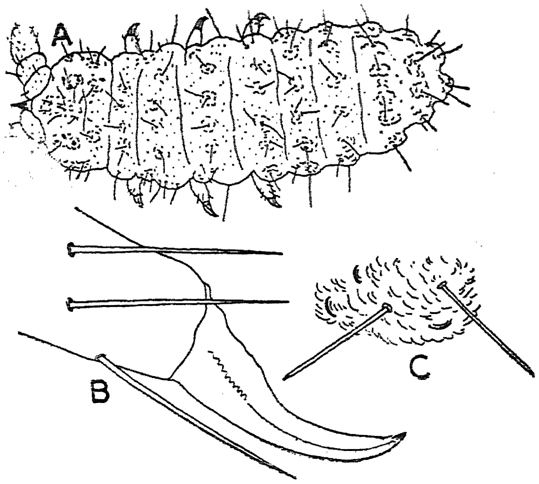



Fig. 2. *Womerselya marhia*, sp. nov.

Length about 2·5 mm (fig. 2). Body colour creamy-white; clothed with long setae, which are longer on the antennae and last abdominal segment; antenna shorter than head; the last two antennal segments indistinctly separated; antennal segment IV with sensory clubs; the four antennal segments in the ratio 8:11:7:9; ocelli 3 on each side; post-antennal organ sbsent; claw long, without inner teeth or tenent hairs (fig 2B); furcula absent.

*Holotype* on slide and *paratypes* in spirit Coll. No. 238/55, Sta. No. 18, Cardex No. 36; on alpine meadow, exposed and windy, feeding on roots under stones with several Coleoptera and Acarina, south slope of Pir Panjal Range, Marhi near base of Rohtang Pass, 3700 m above mean sea level.

This is the first record of the genus *Womersleya* Denis from India.

Family Isotomidae

**Bagnallela santokhi**, sp. nov.

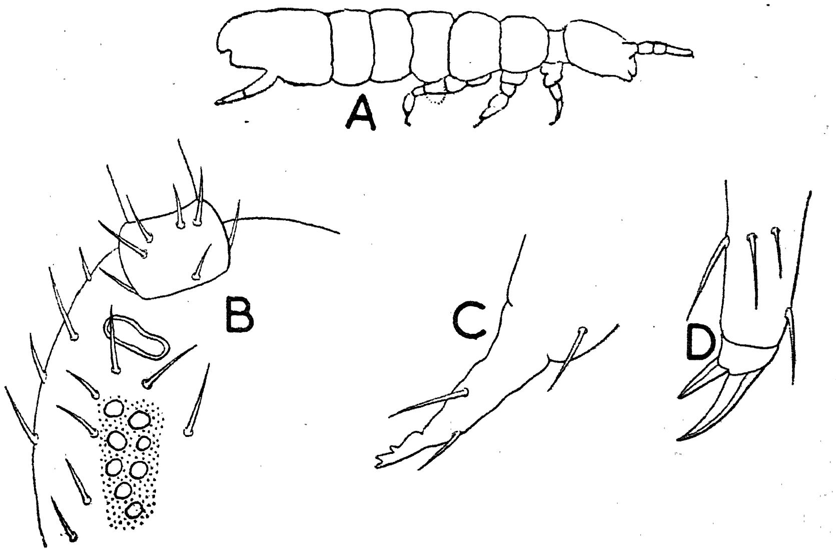



Fig. 3. *Bagnallela santokhi*, sp. nov.

Length about 1·3 mm (fig. 3A). Body colour creamy-white, speckled with purplish-black pigment; ocellar field black; clothed with moderately long, simple setae which are somewhat longer near the posterior end of abdomen; antennae longer than head; with the 4 segments in the ratio 3:3:3:4; antennal segment III with sensory rod; post-antennal organ elliptical and double-outlined (fig. 3B); ocelli 8 on each side on a black patch, regularly arranged and equal (fig. 3B); claw with the inner edge distinctly curved, unarmed (fig. 3D); unguiculus lanceolate; with the inner margin gently truncate and reaching to two-thirds; a small seta on each side of base of claw; tenent hairs absent; abdominal segments IV, V and VI fused together; furcula short, manubrium a little shorter than dens; mucro tridentate; apical tooth very slightly upturned; pre-apical tooth erect; third tooth just forward of the middle, erect and equal to the pre-apical tooth.

*Holotype* on slide and *paratypes* in spirit: Coll. No. 80/55, Sta. No. 26, Cardex No. 73: from under the bark of birch, on north slope of Pir Panjal Range, Lahaul (Upper Chandra Valley), opposite Kulti Nal 3657 m above mean sea level, Coll. Santokh Singh, 10-vi-1955; also several examples Coll. No. 305/55, Sta. No. 26, Cardex No. 75, under birch bark, same locality, Coll. V. K. Gupta, 10-vi-1955. (also above Gramphu alpine Meadow).

This, species is related to *B, octoculata* Handschin, from which it is readily distinguished by the number and arrangement of the ocelli and other characters.

## **Folsomia fimetaria** (Linne)

1929, *Folcomia fimetaria* Handschin, *Rev. Suisse Zool.*, 36:237.

I refer to this species 2 examples, Coll. No. 781/56, Sta, No. 51, Cardex No. 184; stream near north-east end of Sta. No. 39, Chhatru, entrance to Purana Koksar Nal, south slope of Great Himalaya Range, Upper Chandra Valley (Lahaul), formerly glaciated area, 3650 m above mean sea level, coll. H, N. Baijal, 12-vi-1956.

This is the first record of the species from north India (Himalaya). The species is previously known to the distributed in tne Central and Southern Europe, United States of America. (including Alaska), Siberia, Spitzbergen, Franz Josef Land, Greenland, Mexico, Guatemala, Hawaii and South India.

## **Salmonia**, gen. nov.

Ocelli 6 on each side; post-antennal organ well developed and somewhat larger than in the genus *Falsomia* Will.; all setae simple; the suture between the abdominal segments IV and V distinct both dorsally and at the sides; abdominal segments V and Vi fused together completely; furcula short, reaching to the posterior border of abdominal segment II. Genotype: *Salmonia tridentata*, sp. nov.

**Salmonia tridentata**, sp. nov.

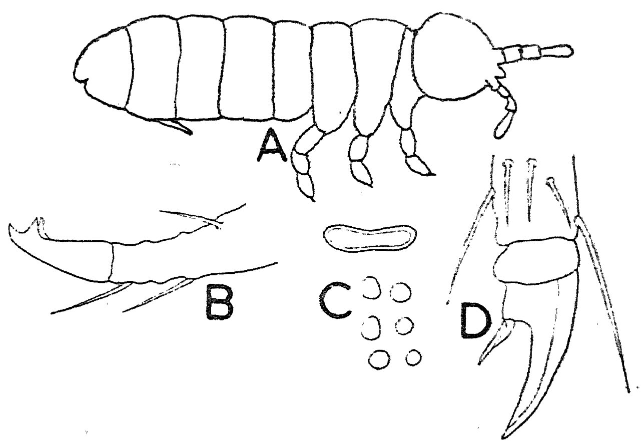



Fig. 4. *Salmonia tridentata*, sp. nov.

Length about 1·0 mm (fig. 4A). Body wholly black when fresh, but somewhat dark bluish-black in mounted specimens; clothed with simple setae, which are longer on the tip of abdomen; antennae a little shorter than head; the four antennal segments in the ratio 2:3:3:6; the fourth antennal segment with numerous olfactory setae; post-antennal organ long, elliptical and double-outlined (fig. 4C.); ocelli 6 on each side (fig. 4C); legs short, stout; unguis curved, unarmed; unguiculus two-thirds of the unguis, with broad innerlamella, which is greatly truncated and reaches to half way down the claw (fig. 4D); tenent hairs absent; a small seta on each side of claw at base; furcula short; dens somewhat longer than manubrium; mucro with strong apical tooth and a pair of larger basal teeth.

*Holotype* on slide and *paratypes* 2 examples in spirit; Coll. No. 248/55A, Sta. No. 24, Cardex No. 48; from damp moss on the edge of melt water stream, Gramphu alpine meadow, Upper Chandra Valley, North slope of the Pir Panjal Range, coll. H. N. Baijal, 7-vi-1955.

**Proisotoma himalayana**, sp. nov.

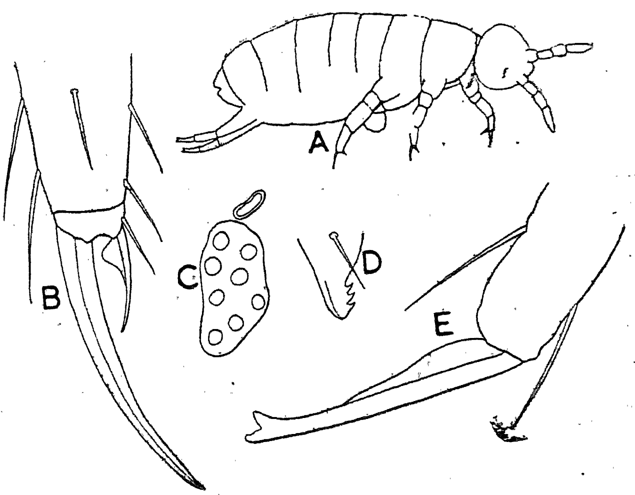



Fig. 5. *Proisotoma himalayana*, sp. nov.

Length 1·2—1·5 mm (fig. 5A). Body colour black in fresh specimens and dark blue in mounted material; clothed with moderately short, simple setae, which are somewhat longer on the posterior part of the body; antennae a little longer than head; antennal segment IV with sense rod; the four antennal segments in the ratio 1:4:4:7; post-antennal organ elliptical, double-outlined; ocelli 8 on each side, subequal (fig. 5C); rami of tenaculum each with 3 barbs; corpus with one seta; unguis elongate, slender, without teeth; unguiculus one-fourth the length of claw (fig. 5B), with broad and nearly semi-circular inner lamella, reaching half way to apex and outer lamella reaching tip; furcula with elongate mucro, with small apicial tooth and subapical/tooth and broad lamella extending back from the subapical tooth to the mucronal base.

*Holotype* one example on slide and *paratypes* numerous examples in spirit; Coll. No. 19/55, Sta. No. 13, Cardex No. 25; on rock partly covered with snow, east of Rahla, south slope of Pir Panjal Range, 3200 m above mean sea level, coll. Santokh Singh, 28-v-1955; also several examples Coll. No. 775/56, Sta. No. 55, Cardex No. 185, alpine meadow, near the north-east corner of Sta. No. 39, at the entrance to Purana Koksar Nal, south slope of the Great Himalaya, Lahaul, from damp moss-covered stones at the edge of melt water stream with temp. 4°C. coll. H. N. Baijal, 12-vi-1956.

This species comes near *Proisotoma nilgiris* Denis[1] and *P. ladaki* Denis[2], but differs in the mucro and the relatively longer claw.

### **Isotoma sarkundensis**, sp. nov.

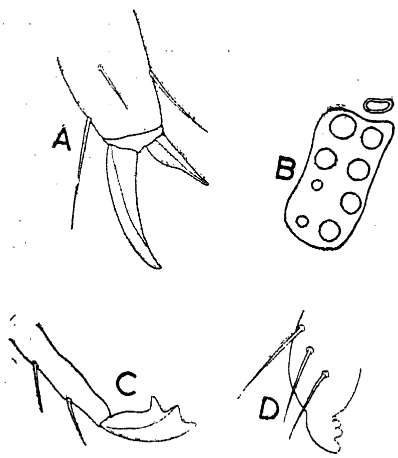



Fig. 6. *Isotoma sarkundensis*, sp. nov.

Length 1·0—1·2 mm. Body colour black when fresh and deep violet inmounted specimen; sparsely clothed with simple short setae; antennae twice the head; antennal segment IV with several straight, erect sensory setae; ocelli 8 on each side, subequal; post-antennal organ elliptical (fig. 6B); rami of tenaculum each with 4 barbs; corpus with 4 setae; unguiculus long and unarmed; unguis broad at base and tapering to a fine point and about two-fifths the length of unguiculus (fig 6A); dens twice the manubrium; mucro short, tridentate, with equal apical and subapical teeth and a small external lateral tooth; manubrial hooks 2; anterior face of dens with corrugations.

[1] Denis, J. R. 1947, *Proc. R. ent. London*, (B) 16:103.

[2] Denis, J. R., 1936, *Mem. Connecticut Acad. Art. & Sci.*, 10:262.

*Holotype* one example on slide and *paratypes* in spirit ; Coll. No. 79/56. Sta. No. 45, Cardex No. 205, on snow on the shore of the Sarkund Frozen Lake on Pir Panjal Range, 4300 m above mean sea level, temp. of water at the edge 0·5°C. taken along with many Plecoptera and Staphylinidae, coll. H.N. Baijal, 19-vi-1956 ; also numerous examples on ice and snow in Seri Glacier Ice Fall, Purana Koksar Nal, Great Himalaya, south slope, Lahaul, 4400 m above mean sea level, coll. H.N. Baijal, 14-vi-1056 (Sta. No. 53, Cardex No. 91).

### **Isotomourus palustris** (Müller)

This species is widely distributed on both south and north slopes of the Pir Panjal, Great Himalaya and nearby ranges, from moist and damp localities, edges of melt water streams and on snow. The maxium altitude up to which the species has been taken is about 4000 m above mean sea level. It is also known to be widely distributed in Europe, Canada, USA, Spitzbergen, Siberia, Bear Island, India, Java and the Azore Islands.

### **Papillomurus indicus**, sp. nov.

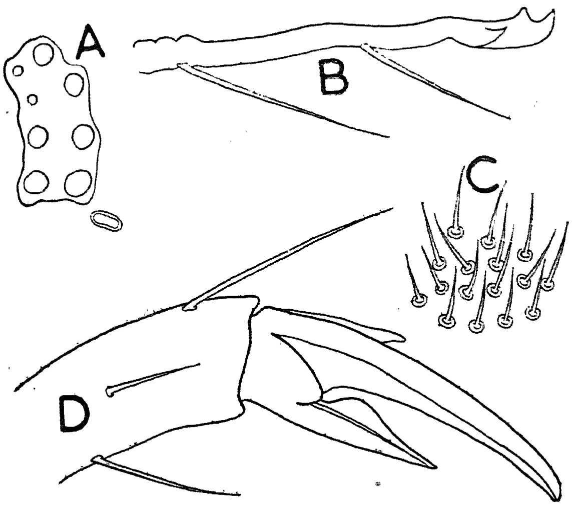



Fig. 7. *Papillomurus indicus*, sp. nov.

Length 1·3—1·5 mm. Body colour bluish-black ; ventrally the body, legs and furca lighter ; clothed with short and long setae ; the longer setae especially prominant on the dorsal surface and the tip of abdomen ; antennae somewhat longer than head ; antennal segment IV with sensory setae ; the four antennal segments in the ratio 7:10:11:13 ; ocelli 8 on each side on black patch ; post-antennal organ elliptical with double-outline, with an indentation in the middle (fig. 7A) ; corpus with 4 setae ; tenaculum with 3 barbs ; unguis broad basally, unarmed in fore and mid legs, with outer tooth on hind leg ; unguiculus half as long as claw (fig. 7D), with very broad, almost semi-circular inner lamella reaching half way from the base ; median outer lamella reaching to tip ; furcula nearly twice the manubrium ; annulated in the posterior face ; mucro short, tridentate, with apical and subapical tooth equal and with a short exterior tooth.

*Holotype* one example on slide and *paratypes* several examples in spirit ; Coll. No. 736/56 Sta. No. 27, Cardex No. 153, Gramphu, Lahaul, north slope of the Pir Panjal Range, 3200 m above mean sea level, coll. H. N. Baijal, 3-vi-1956 ; also numerous examples, Coll. No. 278/55, from under stones near stagnant melt water pool, Kulti Nal, south slope, Great Himalava, (Lahaul), Sta. No. 29, Cardex No. 157 6+ ; Coll. No. 735/56, Sta. No. 27, Gramphu, 3352 m above mean sea level ; specimens taken usually on moss at the edge of melt water torrents.

## Family Entomobryidae

### **Entomobrya nigrita**, sp. now.

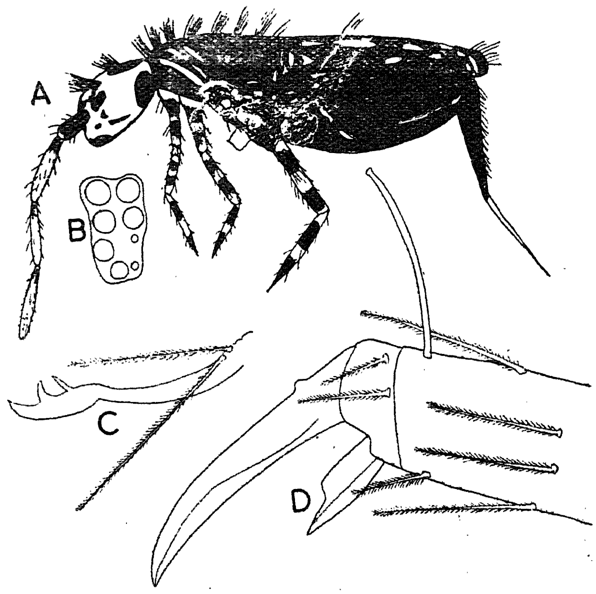



Fig. 8. *Entomobrya nigrita*, sp. nov.

Length about 2·0 mm. Body (fig. 8A) colour black, with irregular yellow pigmentation ; furca creamy-white ; legs and antennae bluish ; thoracic segments I and II with broad irregular spots ; unpigmented patches around anterior margin of abdominal segment IV ; head laterally with deep violet pigmentation, dorsally yellow, but between the ocellar field a broad area of brownish-violet ; clothing dense, with short, ciliated setae and posteriorly with numerous long ciliated setae ; antennae, legs and furca heavily clothed with ciliated setae, often long ; antennae twice the head ; the four antennal segments in the ratio 5:9:9:9 ; ocelli 8 on each side, normally arranged, with front pair largest (fig. 8B) ; abdominal segment IV eight times as long as III ; claw with a pair of outer lateral teeth and a single pair of strong inner teeth just above the middle ; unguiculus truncated on the inner margin and approximately two-thirds the claw ; a single clavate tenent hair just equal to claw on each leg (fig. 8D) ; manubrium to mucrodens in the ratio 32:25 ; the unannulated portion of dens three times as long as mucro ; the mucro joint distinct, mucro rather elongate, bidentate, with basal spine and over-reached by the long ciliated setae ; the two mucronal teeth subequal ; the basal spine long and rising above the subapical tooth.

*Holotype* on slide and *paratypes* numerous examples in spirit Coll. No. 258/55, Sta. No. 24, Cardex No. 47; from edge of melt water stream, Gramphu alpine meadow, Lahaul (Upper Chandra Valley), north slope of Pir Panjal Range, 3500 m above mean sea level, coll. H. N. Baijal and V. K. Gupta, 7-vi-1955 ; also numerous examples Coll. No. 707/56, Sta. No. 43, Cardex No. 134, under pebbles at the edge of melt water stream, Marhi alpine meadow, south slope of the Pir Panjal Range, 3620 m above mean sea level, coll. H. N. Baijal, 26-v-1956 ; Coll. No. 732/56, Sta. No. 27, Cardex No. 153, bank of R. Chandra, 1·6 kilometres above Gramphu, north slope of Pir Panjal, under stones, 3352 m above mean sea level, coll. H. N. Baijal ; Coll. No. 776/56, Sta. No. 51, Cardex No. 185, under stones and on moss at edge of melt water streams, north-east of Sta. 39, Purana Koksar Nal, south slope of the Great Himalaya, coll. H. N. Baijal, 12-vi-1956,

## **Entomobrya longisticta**, sp. nov

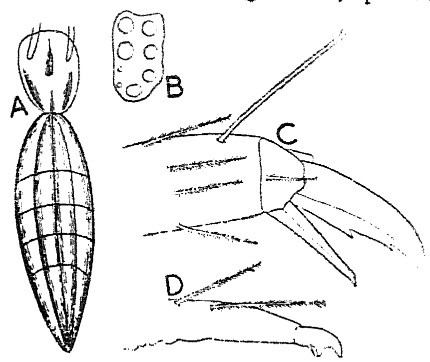



Fig. 9. *Entomobrya longisticta*, sp. nov.

Length 1·7-1·9 mm. Body (fig. 9 A) creamy-yellow, with broad black longitudinal markings along the ventral margins of the pleura, commencing from the base of antennae and continuing unbroken to the posterior margin of abdominal segment IV ; a similar band from mesothorax to abdominal segment V and a narrow stripe right in the middle of head to the abdominal segment V ; body clothed with simple, ciliated setae, occasionally longer setae on body, appendages and tip of abodmen; antennae jus over twice the length of head ; the four antennal segments in the ratio 2:3:3:4 ; ocelli 8 on each side and large except the porterior inner two (fig. 9 B) ; abdominal segment IV about four or five times the III ; claw (fig. C) with a pair of outer lateral basal teeth, with a few large inner teeth at middle and a single tooth at three-quarters ; unguiculus lanceolate, reaching to second inner tooth ; a long clavate tenent hair on each leg ; manubrium to mucrodens in the ratio 9:11 ; dens finely annulated and corrugated ; the uncorrgated portion about twice the lenth of mucro ; the mucro small, bidentate, with basaul spine, surrounded by long ciliated setae ; unannulated portion of dens extending into the base of mucro as a finely serrated lamella.

*Holotype* one specimen on slide, *paratypes* several examples in spirit ; Coll. 402/55, Sta. No. 30, Cardex No. 158, Kulti Nal, south slope of Great Himalaya, Lahaul, 3540 m above mean sea level, coll. H. N. Baijal, 9-vi-1955 ; also several examples Coll. No 742/56, Sta. No. 30 Cardex No. 158, Kulti Nal, coll. H N. Baijal 6-vi-1956, under stones ; Cooll. No. 736/56, Sta No. 27, Cardex No. 153, Gramphu, south slope of Pir Panjal, Lahaul, 3560 m above mean sea level, on moss, about 1·6 kilometres from Gramphu camp to, east, coll. H. N. Baijal 3-vi-1956.

## **Entomobrya kultinalensis**, sp. nov.

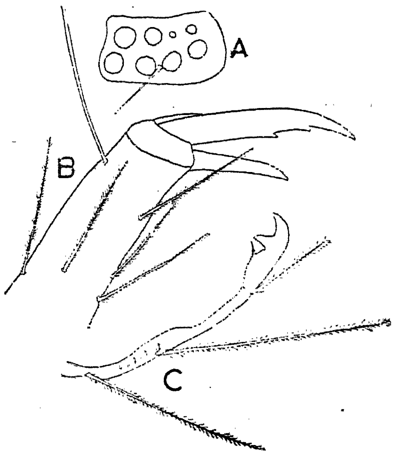



Fig. 10. *Entomobrya kultinalensis*, sp. nov.

Length 1·8 mm. Body gray, with black infumation ; ocellar field black ; antennae pale bluish ; furca and legs yellowish, with black infumation ; clothing of of short, ciliated setae, dorsally and on the edge of the mesotergum the setae flexed; antennae about two and a half times the head ; the four antennal segments in the ratio of 5:12:11:15 ; ocelli 8 on each side, normally arranged, with the front pair largest (fig. 10 A) ; abdominal segment IV about four and one-fourth the III ; claw with a pair of outer lateral basal teeth and with an inner distal tooth at three-quarters and a smaller distal tooth at seven-eights down; ungiculus lanceolate, reaching to three-quarters the claw; (fig. 10 B) a simple clavate tenent hair equal to claw on each leg; manubrium to mucrodens in the ratio 16:21; the unannulated portion of dens two and a half times the mucro and extending as a finely serrated lamella to basal spine of mucro ; the mucrodens just distinct, mucro rather elongate, bidentate, with basal spine and over-reached by long ciliated setae ; the two mucronal teeth subequal, the basal spine long and rising above the subapical tooth.

*Holotype* one example on slide, *paratypes* several examples in spirit ; Coll. No. 756/56, Sta. No. 30, Cardex No. 157, Kulti Nal, south slope, Great Himalaya, under stones, 3540 m above mean sea level, coll. H. N. Baijal, 6-vi-1956 ; also several examples from the same locality, Coll. No. 740/56, Sta. No. 30, Cardex No. 158

### **Entomobrya rohtangensis**, sp. nov.

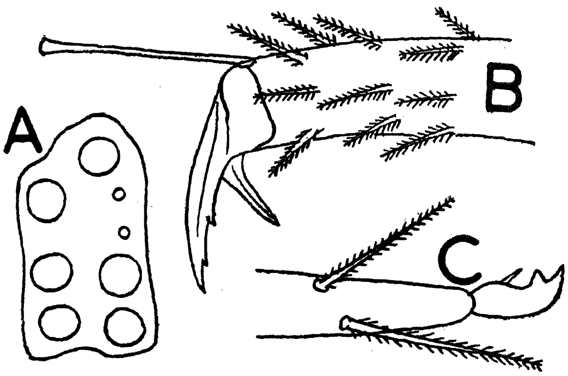



Fig. 11. *Entomobrya rohtangensis*, sp. nov.

Length 1·3 mm. Body greenish-yellow, with black ocellar field and antennae, suffused with black pigment ; legs and furca pale yellow ; clothed with numerous short, ciliated setae and flexed setae, the latter especially on the dorsal surface of head and thorax ; numerous long ciliated setae around tip of abdomen ; legs and abdomen with numerous long setae, except on the terminal antennal segment which has only very fine setae ; two fine ciliated sensory setae on abdominal segment IV ; antennae twice the head ; the four antennal segments in the ratio 2:4:4:5 ; ocelli 8 on deep blue pigmented patch on each side ; the posterior inner two ocelli small (fig. 11 A) ; abdominal segment IV four and a half times the III ; claw with 2 outer lateral basal teeth and 3 inner teeth, of which one pair just in the middle and the third tooth at three-quarters ; unguiculus narrow, lanceolate and about two-thirds the claw; a single ciliated long, clavate tenent hair as long as claw (fig. 11 B) ; manubrium to mucrodens 2:3 ; dens anuulated and corrugated, the unannulated portion about 2·5 times the mucro ; annulated portion of dens extending as a finely serrated lamella to base of mucronal spine ; mucro bidentate, with basal spine, the two teeth subequal ; mucro surrounded by ciliated setae.

*Holotype* one example on slide, *paratypes* several examples in spirit ; Coll. No. 70/55, Sta. No. 29, Cardex No. 69, Kulti Nal, south slope Great Himalaya, (Lahaul), 3500 m above mean sea level, found with Thysanura under stones on alpine meadow, coll. Santokh Singh, 9-vi-1955 ; also numerous series of specimens

Coll. No. 241/55, Sta. No. 21, Cardex No. 39, under stones, alpime meadow below Rohtang Pass, Pir Panjal Range, 4000 m above mean sea level; Coll. No. 276/55, Sta. No. 29, Cardex No. 65, under stones, Kulti Nal, south slope of Great Himalaya, 3500 m above mean sea level; Coll. No. 282/55, Sta. No. 28, Cardex No. 66, under stones, ante nests, with myrmecophilous coccids and ants, Kulti Nal, Great Himalaya coll. H. N. Baijal, 9-vi-1055.

## **Himalanura**, gen. nov.

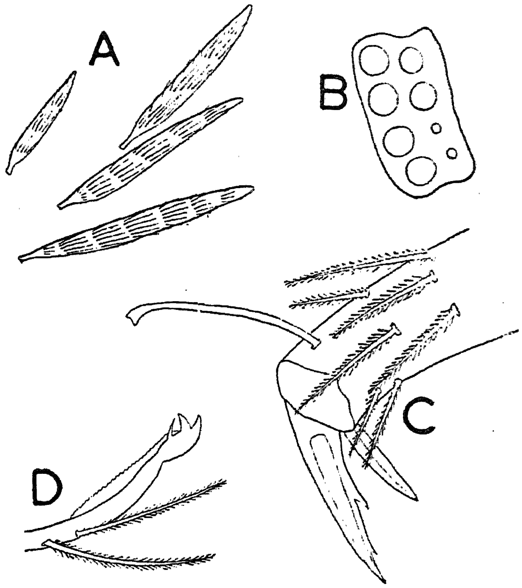



Fig. 12. *Himalanura indica*, sp. nov.

Like *Entomobrya,* but easily distinguished as below: ocelli 8 on each side; clavate tenent setae well developed; mucro bidentate, with basal spine; body clothed with short, peculiar, long, narrowly flattened, scale-like, ciliated setae (fig. 12A). Genotype: *Himalanura indica*, sp. nov.

## **Himalanura indica**, sp. nov.

Length about 1·5 mm. Body deep violet in mounted specimens, with a broad ochreous-brown band along abdominal segments I, V and VI, sometimes thorax and II abdominal segment may be obscurely suffused more or less all over with pale violet: legs, furca and antennae ochreous-brown; ocelli 8 on dark violet pigmented patch (fig. 12B); clothed with short, scale-like ciliated setae dorsally on thorax and abdomen (fig. 12); numerous long ciliated setae on posterior part of abdomen; antennae and legs densely clothed with very long ciliated setae; furcula with many ciliated setae; antennae about one and half times head; the 4 antennal segments in the ratio 3:5:3:4; ocelli 8 on each side, the posterior inner one very small; segmentation rather indistinct on abdomen; abdominal segment IV about five times the III; claw with 3 long (fig. 12C), outer, lateral basal teeth and 2 inner teeth, one pair beyond middle and the third beyond three-fourths; unguiculus narrow, lanceolate and reaching up to three-fourths, as long as claw; a single long, clavate, tenent hair, as long as claw; manubrium and mucrodens in the ratio 5:6; dens corrugated and annulated; the unannulated portion of dens about 4 times the mucro; mucro bidentate, with a single basal spine and surrounded by long ciliated setae.

*Holotype* one example on slide and *paratypes* several series of examples in spirit: Coll. No. 1/55, Sta. No. 10, Cardex No. 10, Rahla, 2750 m above mean sea level, coll. Santokh Singh, 25-v-1955; Coll. No. 52/55 Sta. No. 25, Cardex No 45, Gramphu (Kulti Nal), south slope Great Himalaya, coll. Santokh Singh 6-vi-1956; Coll. 212/55, Sta No. 10, Cardex No. 9, Rahla, coll. H. N. Baijal, 25-v-1955; Coll. No. 206/55, Sta. No. 4, Cardex No. 7, left side of R. Beas, Rohtang road, about 3·2 kilometres from Beas Bridge, about 2000 m above mean sea level (Manali-Koti Road); Coll. 219/55, Sta. No. 7, Cardex No 15, Rahla, on Koti-Rahla road, near Beas River, 2700 m, coll. H N. Baijal, 26-v-1955; Coll. No. 223,/55, 224/55, Sta. No. 8, Cardex No. 22, Rahla, coll. H. N. Baijal, 27-v-1955; Coll. No. 228/55, Sta. 11, Cardex No. 26, Pir Panjal slope on Rohtang road, 2900 m above mean sea level, coll. H. N. Baijal, 28-v-1955; Coll. No. 243/55, 245/55, Sta. No. 18, Cardex No 13. Marhi gang hut 3657 m above mean sea level, coll. H. N. Baijal, 2-vi-1955; Coll. 274/55, Sta. 28, Cardex No. 65, Kulti Nal, south slope of Great Himalaya, 3500 m above mean sea level, coll. H. N. Baijal, 9-vi-1955.

## Suborder SYMPHYPLEONA

## Family Sminthuridae

### **Sminthurus hamtaensis**, sp. nov.

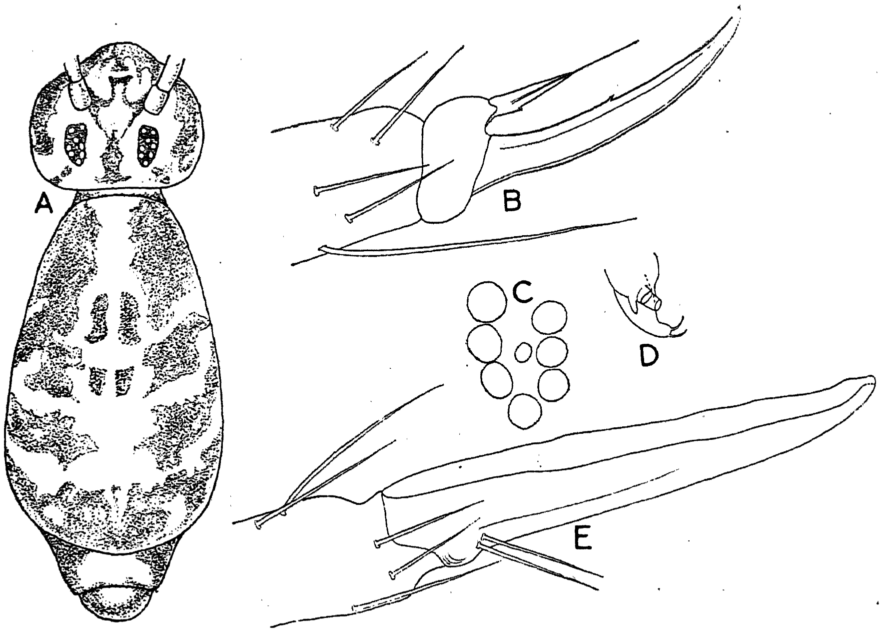



Fig. 13. *Sminthurus hamtaensis*, sp. nov.

Body (fig. 13A) bluish-black, with conspicuous pale yellow markings; head purplish, with broad yellow area between the antennae, the antennae with basal segment dark purple, the apical segment brown; legs yellow, with slight purplish pigmentation; manubrium and dentes essentially pale yellow, with slight purple pigmentation; ventral tube pale yellow; ocellar field dark bluish-black (fig. 13C); clothed with simple long setae, somewhat more dense on the terminal segments; antennae about one and a half times the head; the antennal segment IV with 11-15 obscure subdivions, apically with 5-6 curved sense rods; ocelli with the central one small; 6 large peripheral ones and a posterior small one. much smaller than others; claw (fig. 13B) with larger inner tooth at two-thirds; outer tooth absent; unguiculus lanceolate, slightly more than half as long as claw, with broad curved inner lamella and narrower outer lamella; subapical bristle long and extending beyond tip of claw; both claw and unguiculus finely granulate; no tenent hairs; dens 3 times the mucro; the mucro with lamella plain.

*Holotype* one example on slide and *paratypes* several examples in spirit · Coll. No. 503/55, Sta. No. 37, Cardex No. 90, Hamta Jot, 4400 m above mean sea level, Pir Panjal Range, on rock (sheltered) with many nematocerous Diptera. north-west end of the Hamta pass, coll. Santokh Singh, 16-vi-1955.

# STUDIES IN USTILAGINALES

## 5. MORPHOLOGY AND CYTOLOGY OF *TILLETIA TRANSVAALENSIS* ON *ERAGROSTIELLA BIFARIA* BOR

*By*

N. C. JOSHI*

*Botany Department, Government College, Ajmer (Rajasthan)*

Received on 1st March 1958

### INTRODUCTION

The author while studying some members of Ustilaginales collected an interesting species of *Tilletia*, *T. transvaalensis* in the ovaries of *Eragrostiella bifaria* Bor. in Ajmer and since there is no record of its detailed study the investigations were taken up with a view to work out the morphological and cytological details of this species.

### MATERIAL AND METHODS

Some young and mature infected plants of *Eragrostiella bifaria* were collected from Todgarh. The sori were taken out separately and were exposed to the sun for a whole day, and after they were thoroughly dried, were kept in cellophane bags. The dried spores were later used for the spore germination studies. Various solid and liquid media were employed in spore germination studies. The desired stages of germination were fixed in acetic alcohol, formalin acetic alcohol or Flemming's weak solution and later on bleached with hydrogen peroxide for fifteen minutes and stained with iron alum haemotoxylin. For studying the development of the chlamydospores in the host tissue, the infected parts of various stages were fixed in acetic alcohol and microtome sections of 6 to 10$\mu$ thickness were cut, bleached with hydrogen peroxide and stained with iron alum haemotoxylin and counterstained with Orange G.

### MORPHOLOGY

The sori of *Tilletia transvaalensis* are confined to the ovaries of *Eragrostiella bifaria*, scattered in panicle, replacing the seeds completely. A sorus, on slight pressing releases the spores. The spore mass is black and the spores are reddish brown in colour with a warty epispore, and measure 15 to 16 $\mu$ in diameter (Fig. 1).

### GERMINATION OF THE CHLAMYDOSPORES

The chlamydospores did not germinate in 5 % glucose solution, 5 % lactose solution, distilled water, yeast extract, tap water and 1·5% a sparagine. However 60% germination of the chlamydospores was noticed when the spores were first treated with 10% bleaching powder for 5 minutes and then transferred into moist chamber on the slide and allowed to stay for a week at 5°c. to 8°c. and latter kept

*Present address*—Plant Pathologist, Plant quarantine station (Govt. of India) Alinagar, *Calcutta-24.*

room temperature (20-22°C). The solid media like potato dextrose agar, malt extract agar, 2% agar were employed for the study of spore germination and growth characters of the fungus. The majority of them did not give good results. Malt extract agar gave the best results in this case.

## DEVELOPMENT OF THE CHLAMYDOSPORES IN THE HOST TISSUE

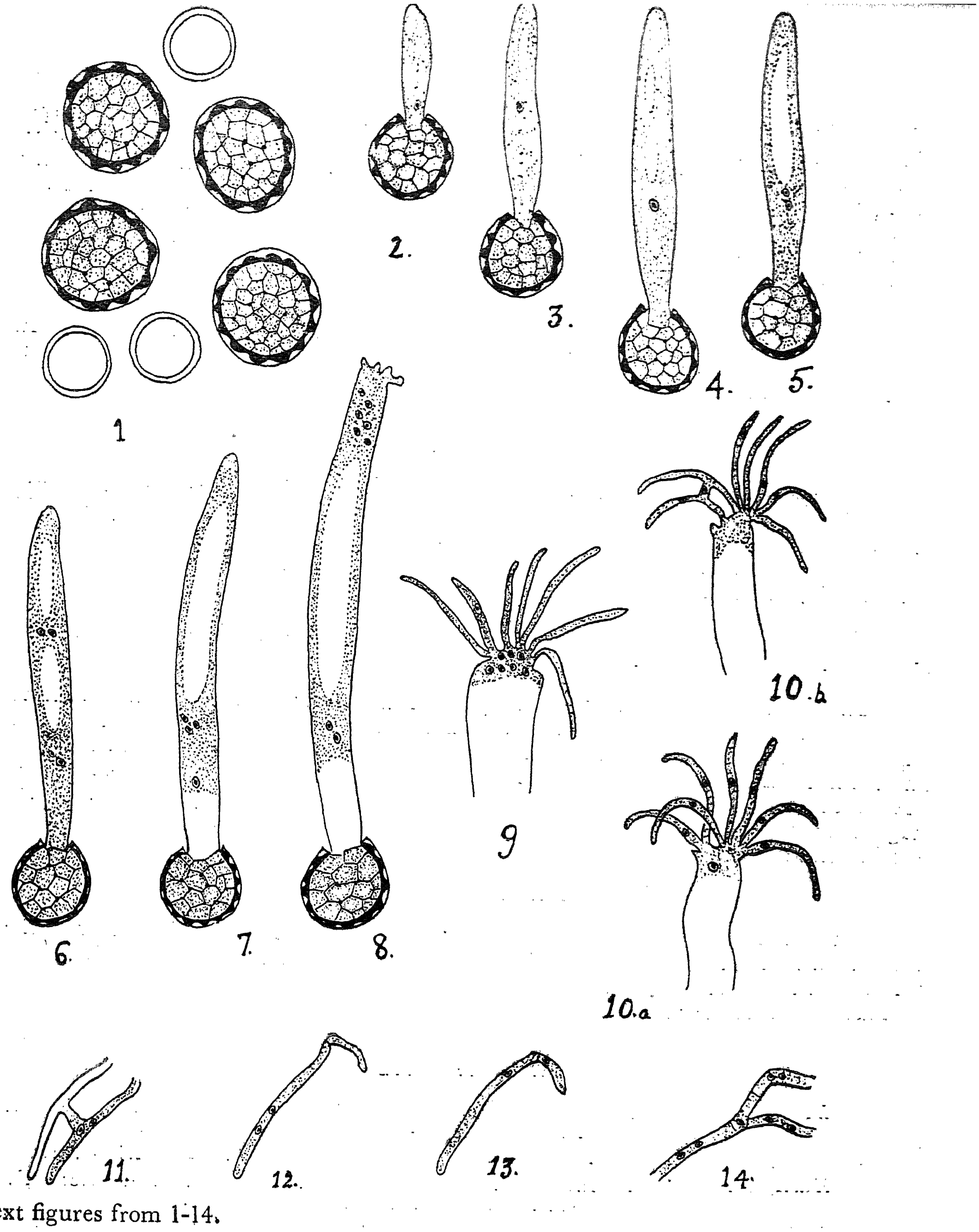
Longitudinal and transverse sections of the infected ovary show the intercellular hyphae which are branched and sparsely septate. The hyphal calls which are binucleate measure 2 to 3·5μ in diameter. The hyphal cells soon swell and the nuclei in each come close together and ultimately give rise to Chlamydospores, which are diploid at maturity. The mature spores are free from each other. Simultaneously the infected host cell also undergoes changes. In earlier stages the ovary cells show a round nucleus but soon after the nuclei of the infected tissue degenerate. The nuclear membrane disappears. The cytoplasm becomes deeply granular The leucoplast from the very beginning starts disorganising and loses its contour and turns black. The cell wall later on ruptures and ultimatley the ovarian cavity is replaced by the chlamydospores.

## SPORE GERMINATION

*Tilletia transvaalensis*, like other species, has a diploid nucleus at the centre of the chlamydospores, with one or two vacuoles. At first the exosporium ruptures, the promycelium comes out. The nucleus migrates undivided into the promycelium (Fig. 2). The migration of the nucleus is immediate. The promycelium increases in length but the width is more or less constant. It measures 8-10μ in width and 70-100μ in length and is unbranched. The nucleus comes near the centre of the promycelium. Soon after, a vacuole is seen at the apical end (Fig. 3) and then a second vacuole appears (Fig. 4). Now the division of the nucleus takes place in the promycelium (Fig. 5), followed by a second nuclear division giving rise to four nuclei (Fig. 6 & 7). Soon after the third nuclear division takes place resulting into eight nuclei (Fig. 8). Out of them six nuclei are seen at the apical end two are at the basal end of the promycelium. In between these two regions there is a big vacuole. Later on, some projections are formed at the tip of the promycelium which soon elongates (Fig. 8). There are several such projections, which develop into sporidia (Fig. 9). In this species only seven sporidia are formed. A single nucleus travels into each sporidium and thus, of the eight muclei, one remains in the promycelium and later on degenerates (Fig. 10a). Now the pairing of the sporidia takes place and the conjugation tubes are formed (10b). Later the migration of the nucleus from one sporidium into the other takes place through the conjugation tube (Fig. 11). The empty sporidium does not develop septa. The primary sporidium now becomes binucleate (Fig. 12), and later gives rise to secondary sporidia (Fig. 13). The secondary sporidia later give rise to the branched hyphae (Fig. 14) The cells of the hyphae are binucleate. The binucleate condition exists for a long time as in *Tilletia tritici* (Paravicini 1917, Rawitscher 1914).

## DISCUSSION

The life history of *Tilletia transvaalensis* resembles very much that of *Tilletia eleusines* (Joshi 1958), *T. holci* (Das 1948) and *T. tritici* (Dastur 1921) with minor differences. In younger stages in this species the sporidia are non-nucleated as in *Tilletia tritici* (Rawitscher 1914), an observation contrary to that of Paravicini (1917)




Text figures from 1-14.

Fig. 1. Mature chlamydospores. $\times$ 1200 times
Fig. 2. Early germinating stage of a spore with diploid nucleus in the promycelium. $\times$ 1200 times.
Fig. 3. Spore with the promyeclium having a small vacuole at the apex $\times$ 1200 times.
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Fig. 9. Development of seven sporidia. $\times$ 1200 times.
Fig. 10a. Migration of the nuclei into the sporidia $\times$ 1200 times.
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Fig. 11. Migration of the nucleus of one sporidium into the other. $\times$ 1200 times.
Fig. 12. Formation of secondary sporidia at the tipe of the primary one. $\times$ 1200 times.
Fig. 13. Mature Secondary dinucleate sporidium. $\times$ 1200 times
Fig. 14. Binucleate hyphae arising from a secondary sporidium. $\times$ 1200 times.

who thinks that the sporidia in *Tilletia tritici* are nucleated even at a young stage. The sporidia, uninucleate in nature, are directly in continuation with the promycelium as in *Tilletia tritici* (Dastur 1921). Soon after as in *Tilletia tritici* (Dastur 1921), conjugation tubes are formed in between two sporidia at the lower region. The nucleus of one sporidium migrating into the other results in the binucleate primary sporidium as observed in *Tilletia holci* (1948) and *Tilletia eleusines* (Joshi 1958), but unlike *Tilletia caries* and *T. foetida* (Hanna 1934) where they are uninucleate.

The secondary sporidia directly give rise to the dicaryotic mycelium. In this respect the author's observations agree with those of Paravicini (1917), Rawtischer (1914) and Dastur (1921), working on *T. tritici*.

## SUMMARY

The spore mass of *Tilletia transvaalensis* is brownish black and the spores are reddish brown and has a warty epispore. The mature chlamydospores are diploid and 60% of the spores germinated when they were first treated with bleaching powder and then kept between 6-8°C for a week and later on kept at room temperature, *i.e.* 24-22°C.

The spores on germination give rise to a long septate promycelium and seven sporidia are developed at the tip.

The division of the nucleus takes place in the promycelium. A single nucleus enters in each sporidium and one nucleus remains in the promycelium which later on, probably, degenerates. The conjugation tube develops between two sporidia and the nucleus of one goes into the other which becomes binucleate and gives rise to the dicaryotic mycelium that later on forms the chlamydospores. In earlier stages they are binucleate but become diploid at maturity. The epispore is warty and brown in colour.

## ACKNOWLEDGMENT

The author wishes to express his gratitude to Dr. G. W. Fischer Head of the Department of Plant Pathology, State College, Washington, U. S. A. for going through the manuscript. He is also thankful to Principal Bhim Sen and Prof. B. Tiagi for laboratory facilities.

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# ON THE BIONOMICS AND LIFE-HISTORIES OF THREE SPECIES OF *AULACOPHORA* (CHRYSOMELIDAE : COLEOPTERA) FROM INDIA

*By*

R. S. SAINI

*Department of Zoology, University of Saugar, India*

Received on 31st January 1958

## INTRODUCTION

Species of *Aulacophora* damage crops belonging to Cucurbitaceae. Some notes on the life-history of *Aulacophora* were published by Hussain and Shah (1926), Maulik (1936) and Narayanan (1953). Boving (1927 and 1931) has described the larvae of *Diabrotica* and *Phyllobrotica*, which are closely allied to *Aulacophora* and are found as pests of cucurbit plants in N. America. This account deals with some aspects of the life-histories of three common species, *Aulacophora foveicollis* Luc., *A. atripennis* Fab. and *A. cincta* Fab. from India. An attempt is also made to differentiate the eggs of the three species by sculpturing of the Epichorion and the larvae by pronotal and pygidial chaetotaxy.

## MATERIAL AND TECHNIQUE

The life-history of the insects was studied both in the field and in the laboratory. In the field cylindrical wire gauze cages, with three spike-like legs towards the lower open end, were used. The cages were fixed in position by simply pressing them down so that the spikes were fully embedded in the soil. The cages could be easily withdrawn when necessary by pulling them out. In the laboratory, insects were reared in covered petri dishes, with a layer of moist earth about one inch in thickness at the bottom. The adults were provided daily fresh leaves of the food plants. The larvae were reared on the petioles of food plants and not on the roots and it was noticed that they fed actively on the petioles and thrived quite well in captivity.

## OBSERVATIONS

Distribution : The genus *Aulacophora* is widely distributed in India. *A. foveicollis* is found all over India, though more abundant in the North than in the South; *A. atripennis* is found in the northern and central parts of India, but is absent from the southern pennensular portion. *A. cincta*, on the other hand, is confined to the Deccan region and is not found in the nothern parts of the country.

Life-histry : Adults begin to emerge after hibernation sometime in March. In plains of the north India, they appear early in March, but in more southern regions, they appear late in March. They remain active up to November and thus the winter varieties of the vegetable crops are mostly not attacked. *A. atripennis* has sometimes been observed at Saugor, as late as early January, on *Lagenaria vulgaris* but at this time they are practically harmless to the plants. The insects usually hibernate among the ratoons of cucurbit plants or among the roots of *Tagetes erecta, Mentha viridis*, etc.

Copulation: Copulation takes place several times in laboratory as well as in the field during the season (from middle of March to October). The normal period of mating in *A. foveicollis* and *A. atripennis* is about four hours, but in some cases, especially in the autumn and beginning of the winter, the period is greatly prolonged and varies from 4-12 hours. Eggs are laid 2-3 days after copulation and the first batch of eggs are laid in about a week after emerging from hibernation. At Saugor, both the species appear late in March and the first batch of eggs are laid by the end of March or early in April.

*The Eggs. (Fig. 1, A, B, C)*:

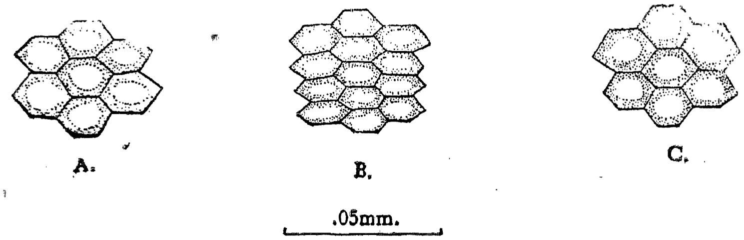

Fig. 1. Diagrams showing part of the egg, highly magnified to show the sculpturing of the egg-shell of :—
(A) *Aulacophora foveicollis* Luc.
(B) *A. atripennis* Fab.
(C) *A. cincta* Fab.

The eggs are laid on moist earth and in crevices at the base of the food plants. In the laboratory eggs are deposited on moist earth in sheltered places, but in shallow petri dishes, eggs are sometimes laid inside the folded and rolled up leaves of the food plants. Dark sheltered and moist places close to their food plants are thus preferred for oviposition.

The number of eggs laid at any one time varies with species as given in the following table :

| Name of species | No. of eggs laid at a time | No. of Eggs arranged in a group | Temprature |
|---|---|---|---|
| *A. foveicollis* ... | 40 - 60 | 8 - 10 | 30°C |
| *A. atripennis* ... | 40 - 70 | 12 - 16 | 30°C |
| *A. cincta* ... | 80 - 100 | 10 - 12 | 30°C |

*A. foveicollis*: The freshly laid eggs are spherical and deep yellow in colour. The size of eggs is 0·87 mm in diameter and its epichorion is finely sculptured and is divided into a number of regular hexagonal areas.

*A. atripennis*: The freshly laid eggs are spherical and light yellow in colour. The size of eggs is about 0·69 mm. in diameter and its epichorion is marked with narrow and elongated hexagonal areas.

*A. cincta*: The freshly laid eggs are spherical and deep yellow in colour. The size of eggs is about 0·89 mm in diameter. The sculpturing of the epichorion takes the form of regular hexagons.

| Name of species | | Size of eggs | Colour | Sculpturing of epichorion |
|---|---|---|---|---|
| *A. foveicollis* | ... | 0·87 mm | Deep yellow | regular hexagonal areas |
| *A. atripennis* | ... | 0·69 mm | light yellow | narrow hexagonal areas |
| *A. cincta* | ... | 0·89 mm | deep yellow | regular hexagonal areas |

The eggs turn darker with age in all the three species.

The egg stage lasts from 5—8 days. The rate of development depends chiefly on the temprature as given below.

| Month | | Temperature | Duration of the egg stage |
|---|---|---|---|
| April to June | ... | 38-40°C | 5-6 days |
| July to September | ... | 30°C | 7 days |
| October | ... | 27°C | 8 days |

During this period the eggs become somewhat elongated and present an oval appearance. The egg membrane is opaque and thus the parts of the larva cannot be made out through it.

*The Larva (Figs. 2, 3A, B, C, and 4A, B, C)*:

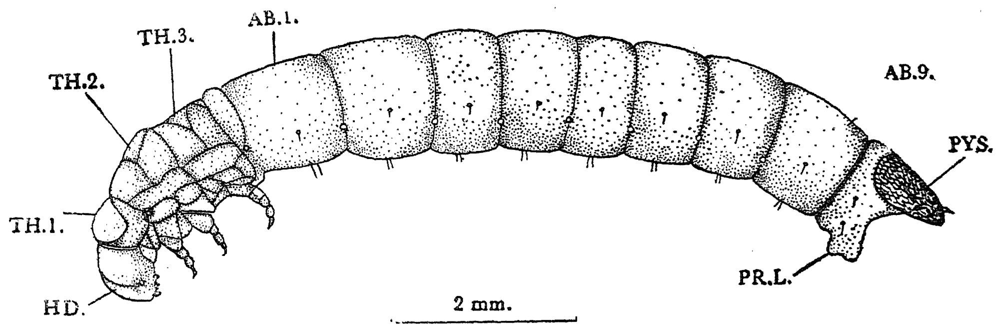


Fig. 2. Diagram showing a fourth instar larva of *A. foveicollis*.

The larval life lasts from 14 to 18 days, during which period three moults are undergone.

The first instar is, as a rule, of about two days, measuring 1·4 to 2 mm in length, the second instar of about 3 days, measuring 2·5 to 4 mm in length, the third

instar of about 3 days, measuring 4 to 5 mm in length, and the fourth instar of about 6 days, measuring 7 to 12 mm in length, i. e., till it pupates.

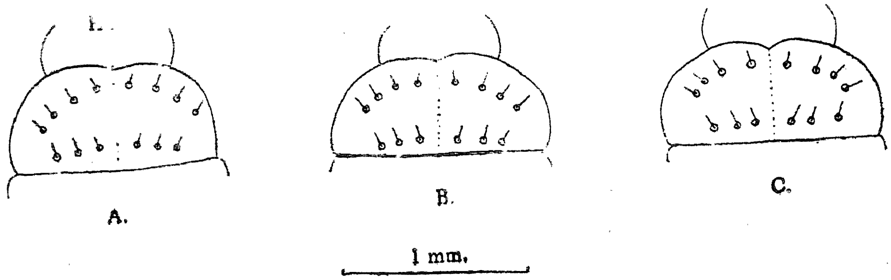


Fig. 3. Diagram showing the pronotum of a fourth instar larva to show the arrangement and size of the setae of:—

(A) *A. foveicollis.*

(B) *A. atripennis.*

(C) *A. cincta*

After the end of larval stage, the larva burrows about half an inch or more below the surface of the soil, and constructs an oval earthen cell by the contortions of its body. This earthen cell is the pupal chamber.

The fourth stage or fully developed larva in the three species does not vary very much in size but measures 11·5 mm to 12·5 mm long and 1·2 mm broad. The larva is of the eruciform type, with a cylindrical body provided with three pairs of rather long and slender thoracic legs. The body is divided into a head, three distinct thoracic and nine abdominal segments. In this stage, the body is yellowish-white but the head, the pronotal shield, the joints of the legs and the pygidial shield are more strongly sclerotized and darker in colour than the rest of the body. Ocelli are absent.

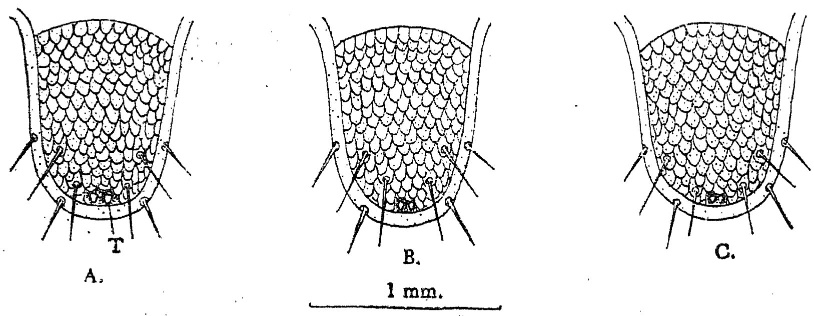


Fig. 4. Diagram showing the pygidial shield of a fourth instar larva to show the arrangement and size of the setae and tubercles on surface of :—

(A) *A. foveicollis.*

(B) *A. atripennis.*

(C) *A. cincta.*

The setae on pronotum and pygidial shield are especially well developed and are of taxonomic value. These setal arrangements are remarkably constant throughout larval life and thus they apply in general to all the instars.

In *A. foveicollis* on each side the pronotum is provided with four setae in the anterior row and three in the posterior row and all the seven setae are equal in size. The pygidial shield on each side is provided with two dorsal and two ventral setae and a pair of prominent dorsal tubercles between the posterior dorsal setae.

In *A. atripennis* on each side the pronotum is provided with four setae in the anterior row and three in the posterior row and here the mesial setae of the first row is much smaller than the other six setae. The pygidial shield on each side is provided with two dorsal and two ventral setae and is with two less prominent tubercles between the posterior dorsal setae.

In *A. cincta* on each side the pronotum is provided with four setae in the anterior row and three in the posterior row and all the seven setae are equal in size. The pygidial shield on each side is provided with two dorsal and two ventral setae and with two greatly reduced tubercles between the posterior dorsal setae.

These characters are summed up as follows.

| Species | Pronotal setae | Dorsal tubercles of the pygidial shield |
|---|---|---|
| *A. foveicollis* ... | Mesial setae of the anterior row are of the same size as the rest of the setae. | Dorsal tubercles are very prominent. |
| *A. atripennis* ... | Mesial setae of the anterior row are much smaller than the rest of the setae. | Dorsal tubercles are not so prominent as in *A. foveicollis*. |
| *A. cincta* ... | Mesial setae of the anterior row are of the same size as the rest of the setae. | Dorsal tubercles are greatly reduced. |

*The Pupa (Fig. 5):*

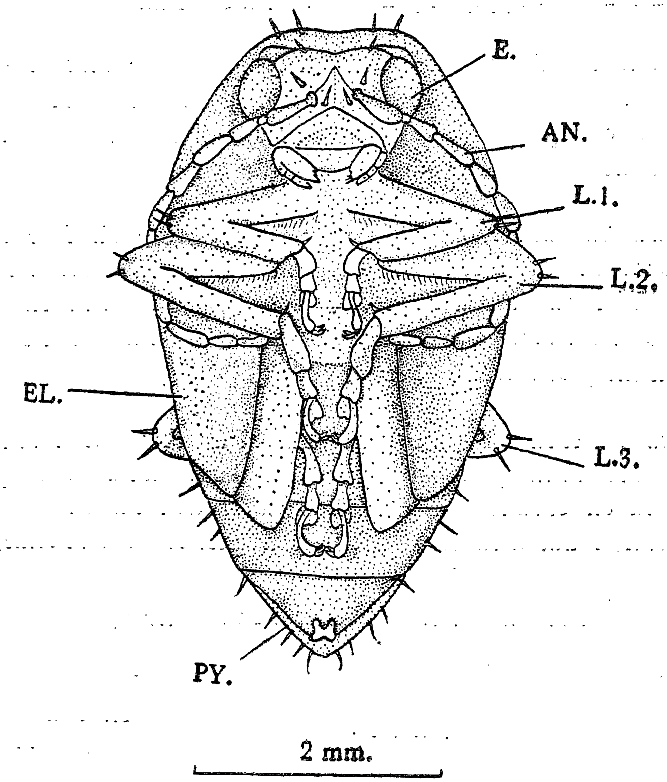


Fig. 5. Diagram showing the pupa (Ventral view) of *A. foveicollis.*

The pupal stage is of 12 to 16 days duration. The pupa measures 6·5-7·5 mm long and 3·3-3·7 mm broad, but in preserved specimens, in which the abdomen becomes expanded, the length in an average specimen is about 8 mm. The pupa is of the exarate type, with a strongly deflexed head and with the antennae, wings and legs free from, but closely applied to the body. The body is uniformly yellow to yellowish-orange. The ventral side is glabrous but the dorsal surface is provided with some whitish setae. The pronotum forms a broad plate, partly covering the head. The mesothorax is smaller than the metathorax. The abdominal segments are comparatively short and reduced posteriorly. The elytra and wings are curved on to the ventro-lateral surface of the body, passing between the second and third pairs of legs. They cover the femur and the tibia of the last pair of legs, but they do not meet ventrally. The first and second pairs of legs are sharply bent at the femurotibial joint which project beyond the elytra. The antennae are closely applied to the surface of the elytra and curve round the femora of the second pair of walking legs to extend behind the tibia up to its tibio-tarsal joint. The eyes, mouth parts, antennae and legs, etc., of the adult can be easily distinguished.

SUMMARY

1. The eggs of *Aulacophora* are spherical. They are largest in *A. cincta*, smallest in *A. atripennis*, and intermediate in size in *A. foveicollis*. In the latter and in *A. cincta*, the sculptring of the egg shell takes the form of more or less regular hexagons, but in *A. atripennis*, they take the form of elongated hexagons.

2. The larvae are slender, eruciform and whitish-yellow. Ocelli are absent. Setae on pronotum and pygidial shield are of diagnostic importance. In *A. foveicollis* all the pronotal setae are of the same size and the dorsal tubercles of the pygidial shield very prominent. In *A. atripennis* the mesial setae of the anterior row of the pronotal shield are much smaller than the rest of the setae and the dorsal tubercles of the pygidial shield are not very prominent. In *A. cincta*, all the setae of the pronotal shield are of the same size, but the dorsal tubercles of the pygidial shield are very much reduced.

3. Pupation is in a cell in the soil among the roots of cucurbit plants.

4. The adults hibernate among the ratoons of cucurbit plants and roots of other plants like *Mentha viridis, Tagetes erecta*, etc.

ACKNOWLEDGMENT.

The author has great pleasure in expressing his indebtedness to Professor D. S. Srivastava for his valuable guidance.

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KEY TO LETTERINGS

| | | |
|---|---|---|
| AB. 1.—AB. 9. | ... | Abdominal segments 1 to 9. |
| AN. | ... | Antenna. |
| E. | ... | Eye. |
| EL | ... | Elytra. |
| HD | ... | Head. |
| L1—L3 | ... | Walking legs 1 to 3. |
| PR. L. | ... | Pro-leg. |
| Py | ... | Pygidium. |
| Py. S. | ... | Pygidial shield. |
| T. | ... | Tubercle. |
| TH. 1—TH. 3 | ... | Thoracic segments 1 to 3. |

## CONTENTS




The Mission Press, Allahabad.